Network Architecture

Lessons from the past,

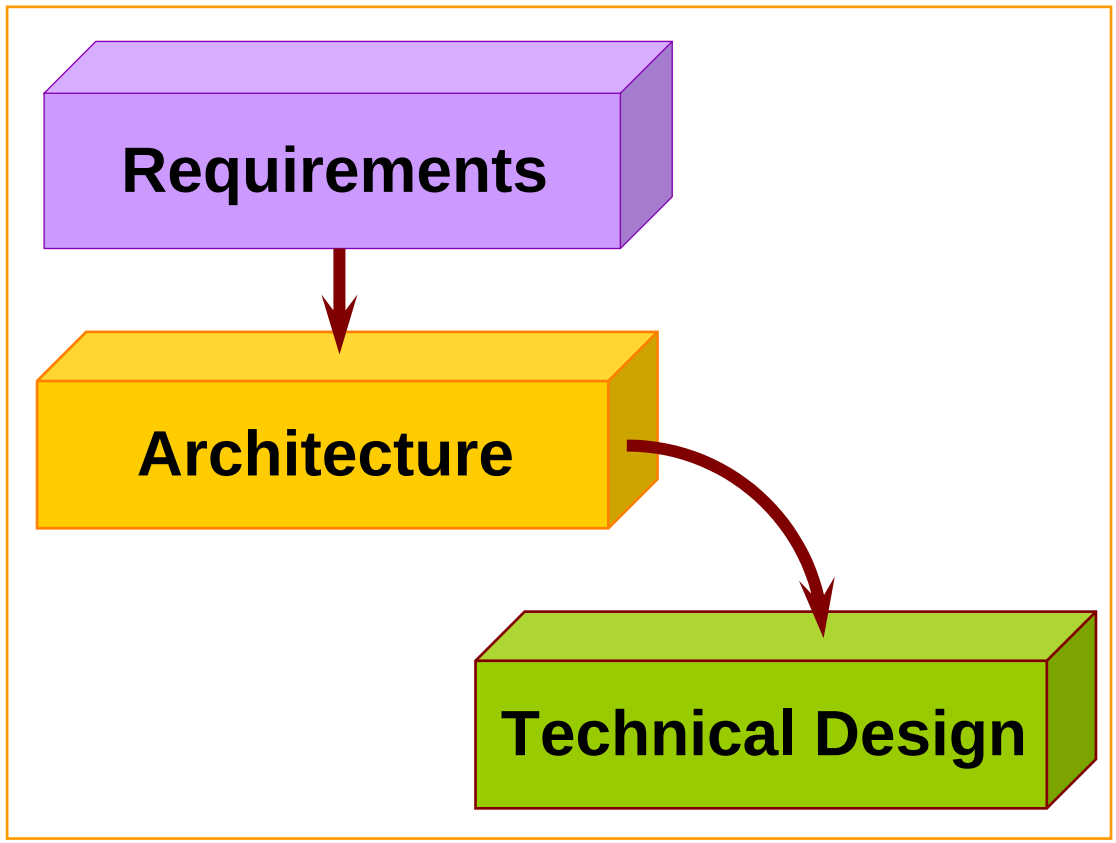
Vision of the Future

François Fluckiger, CERN

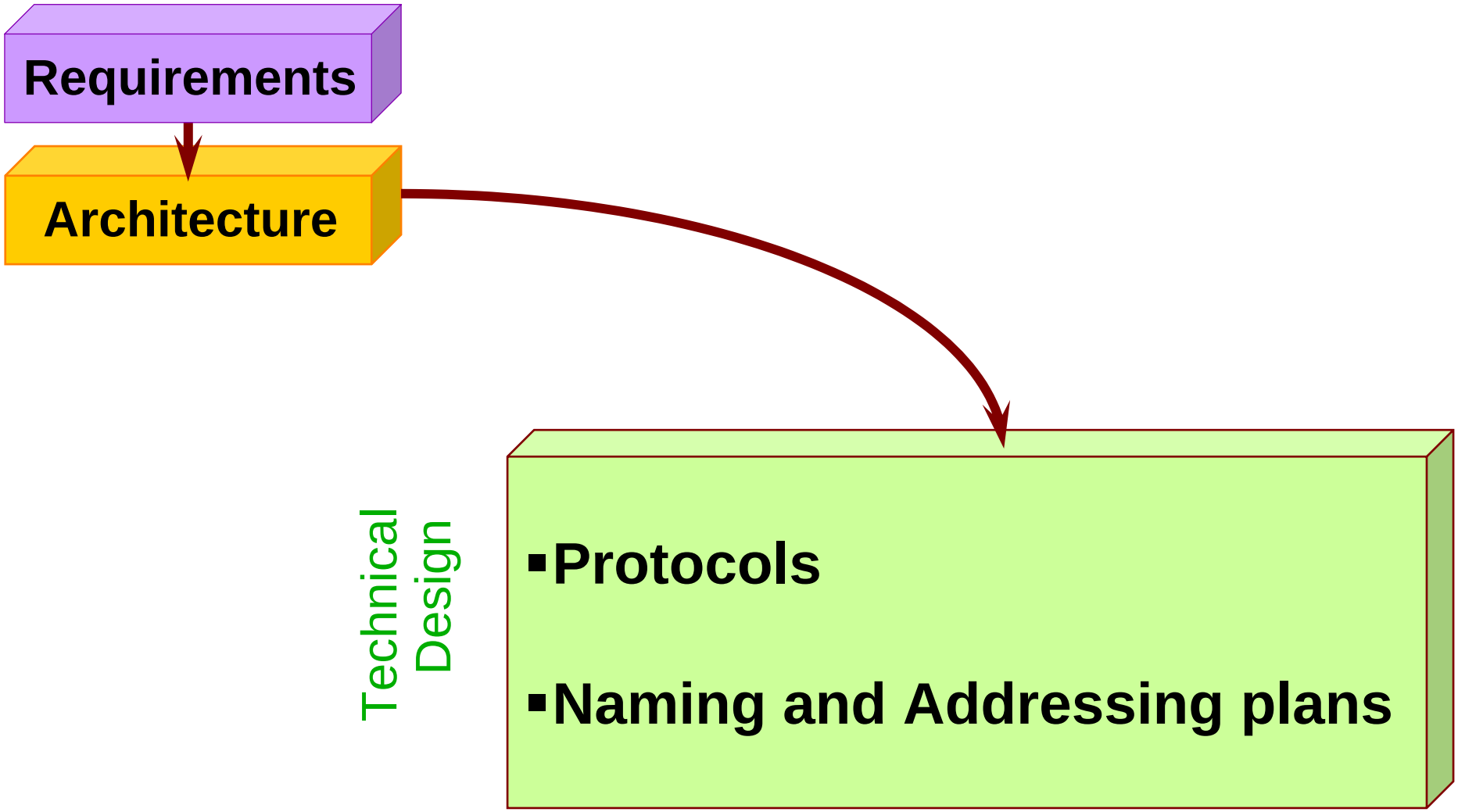
Theory

What is a Network Architecture

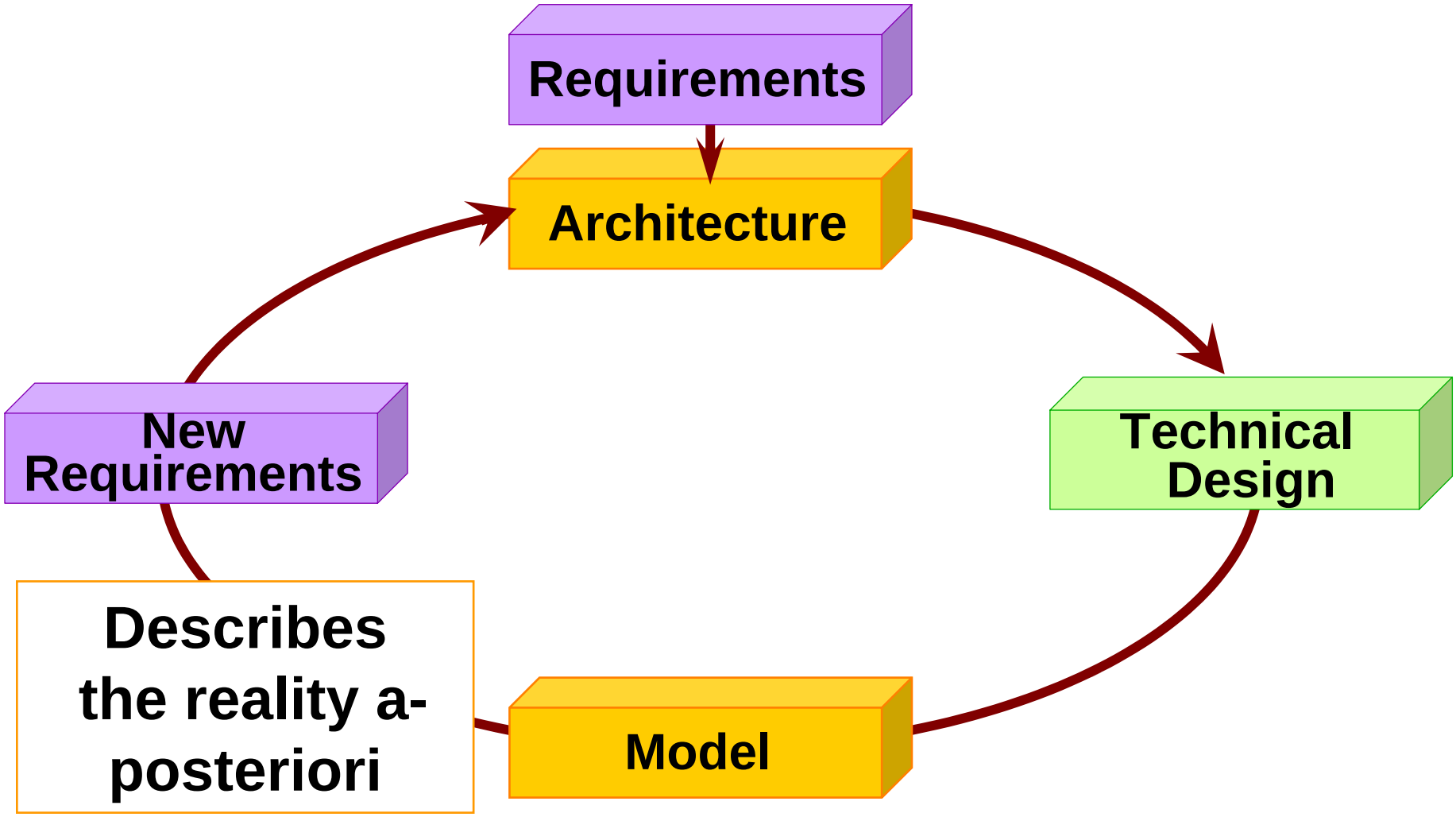
"A set of abstract principles for the Technical Design of communication systems "



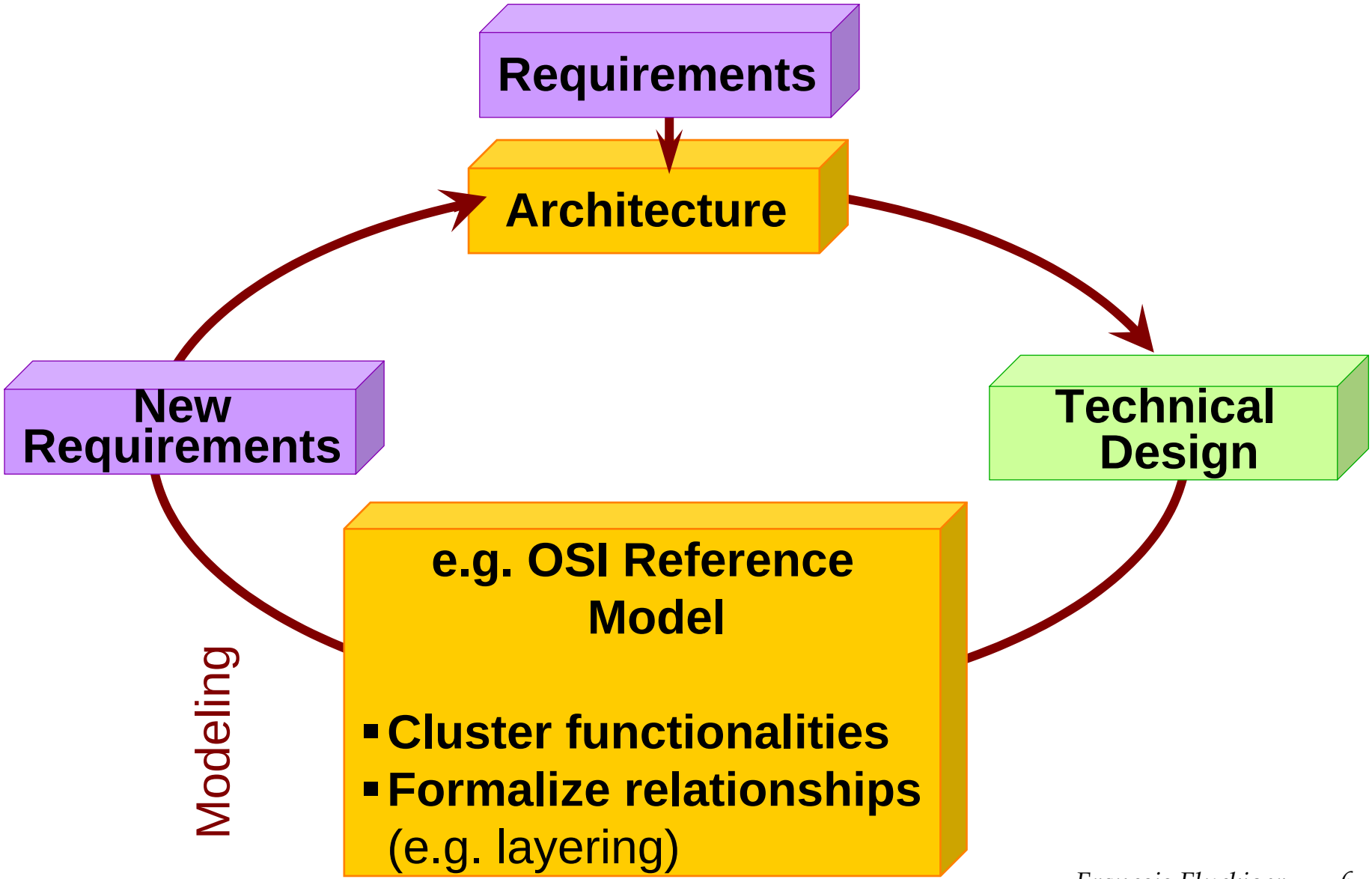
From Architecture to Technical Design



Feedback, Modeling



Modeling


Requirements
Architecture
Technical Design
New Requirements
Modeling
e.g. OSI Reference Model
Cluster functionalities
Formalize relationships
(e.g. layering)

Practice

Internet Architecture (in 84)

Requirements

- Functionality
- Robustness / Survivability
- Scalability
- Predictability
- Performance Guarantees

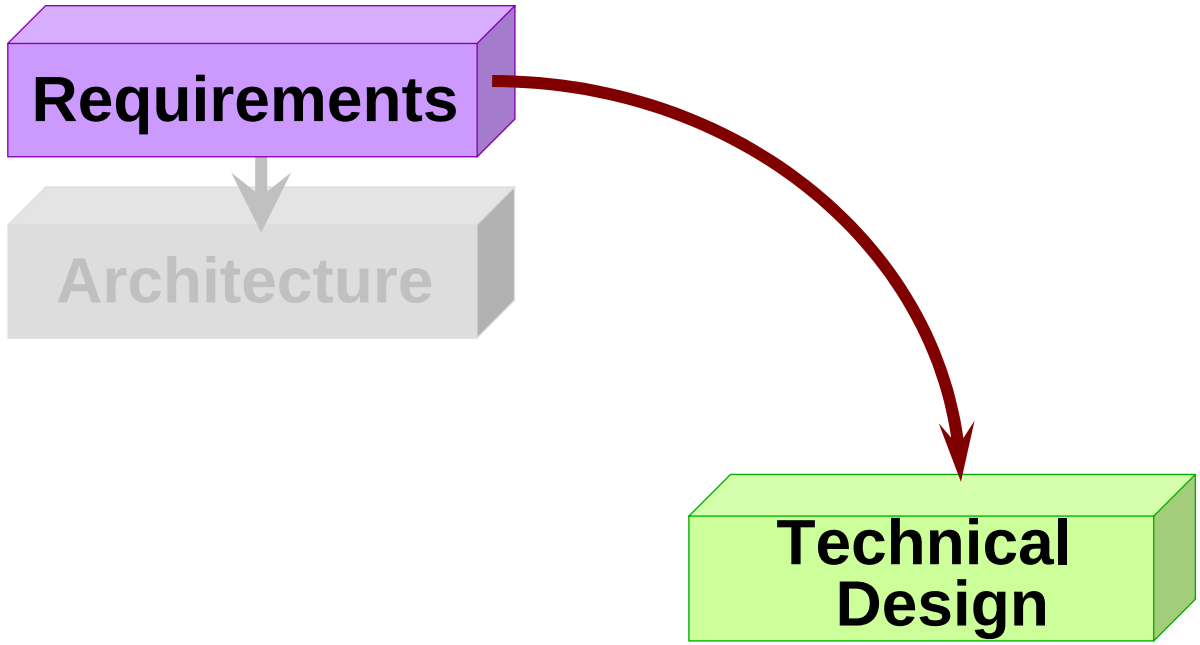
- **One-to-one, bidirectional**
- **Maximum**
- **Good**
- **Fair**
- **None**

Architecture

1. Centralization
2. Network Intelligence
3. Network Components
4. States
5. Addressing
6. Traffic prioritization
7. Security Boundaries

1. **Zero**
2. **Minimum** (E2E argument)
3. **Nodes and Hosts**
4. **Stateless**
5. **Fixed size, numerical**
6. **None**
7. **Within end-systems**

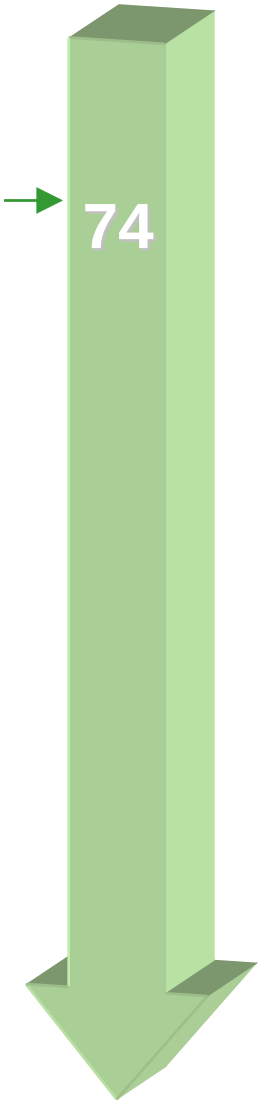
Internet History



TCP / IP Separation

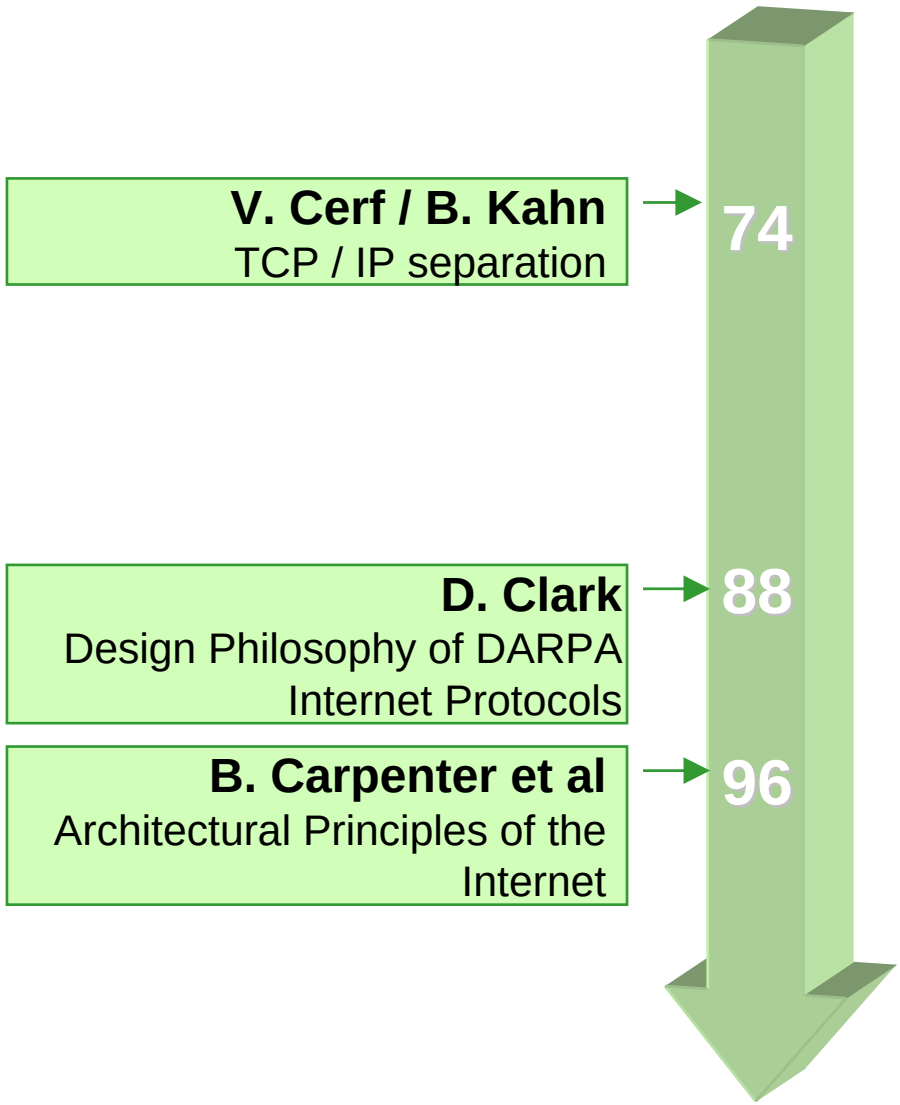
Transport Level

V. Cerf / B. Kahn
TCP / IP separation



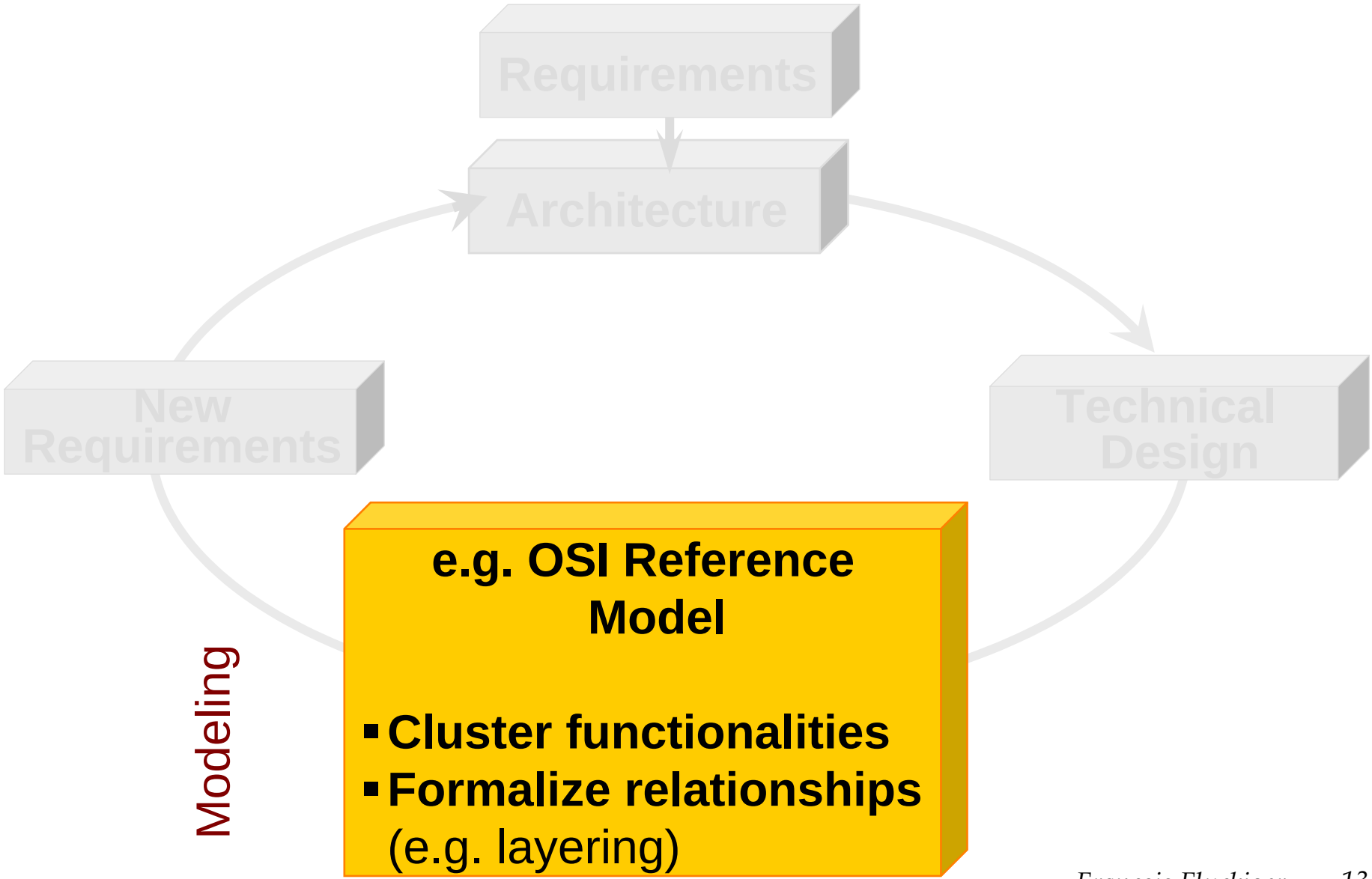
Internet Architecture Formalization

Transport Level



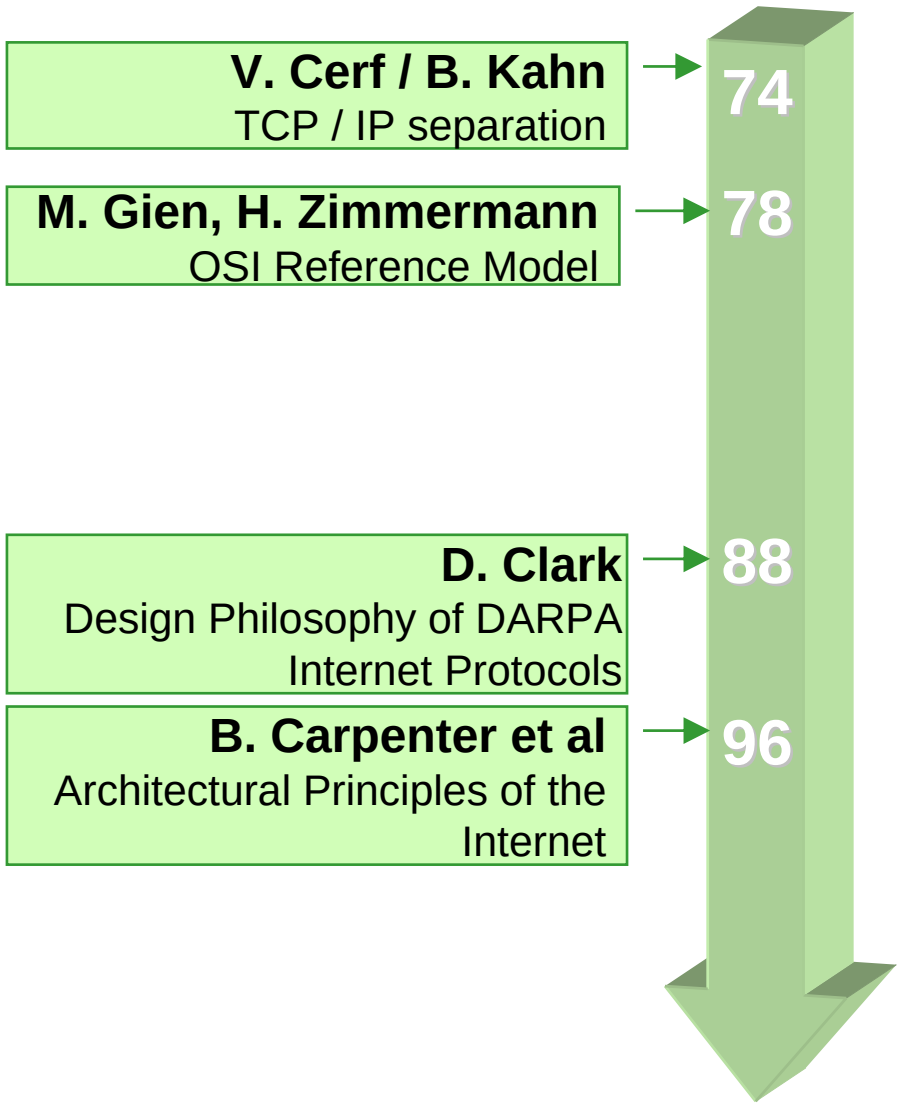
Onions and Cupboards

Modeling

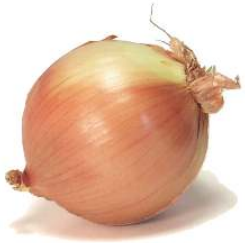

Requirements
Architecture
New Requirements
Technical Design
Modeling
e.g. OSI Reference Model
Cluster functionalities
Formalize relationships
(e.g. layering)

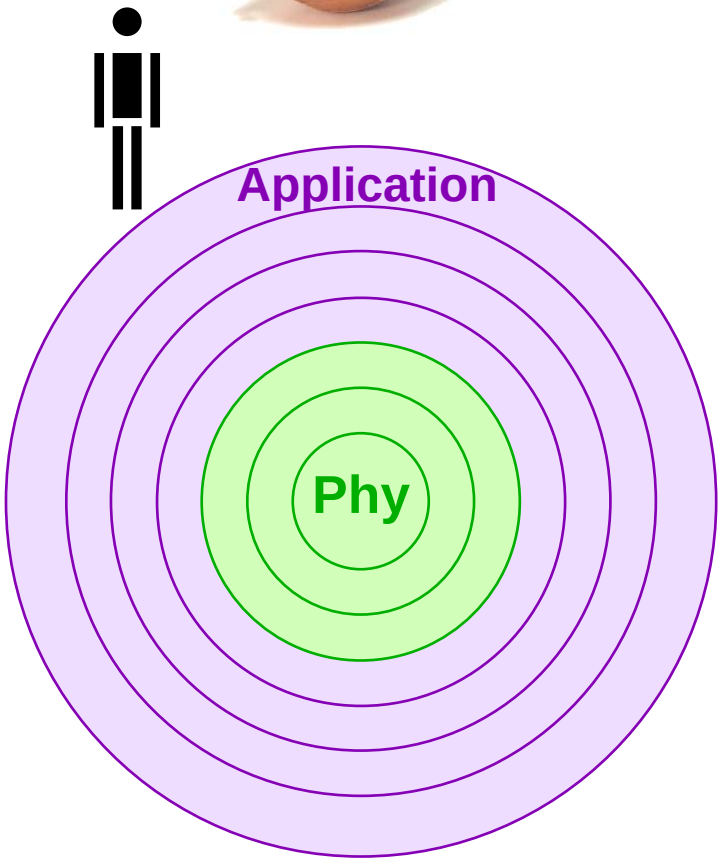
A-posteriori Modeling

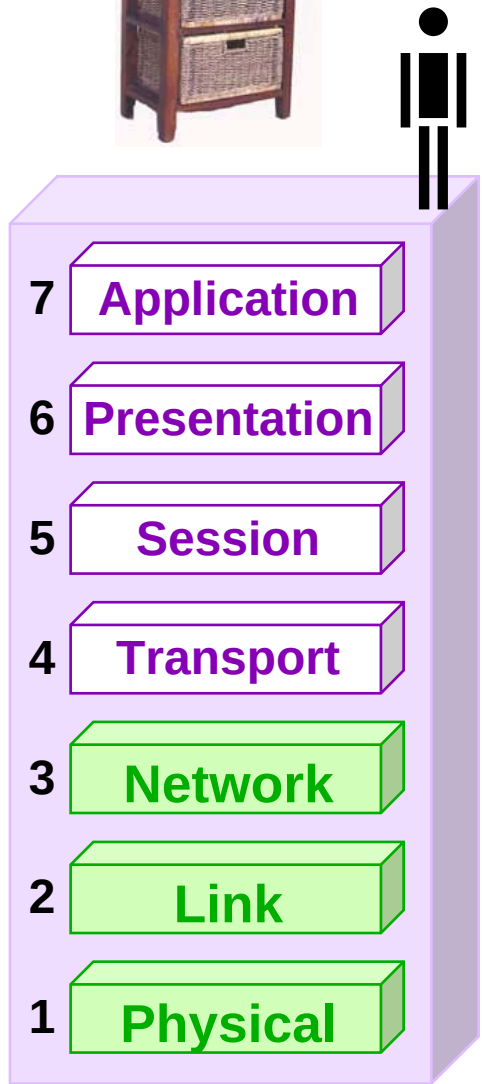
Transport Level



Layering principle



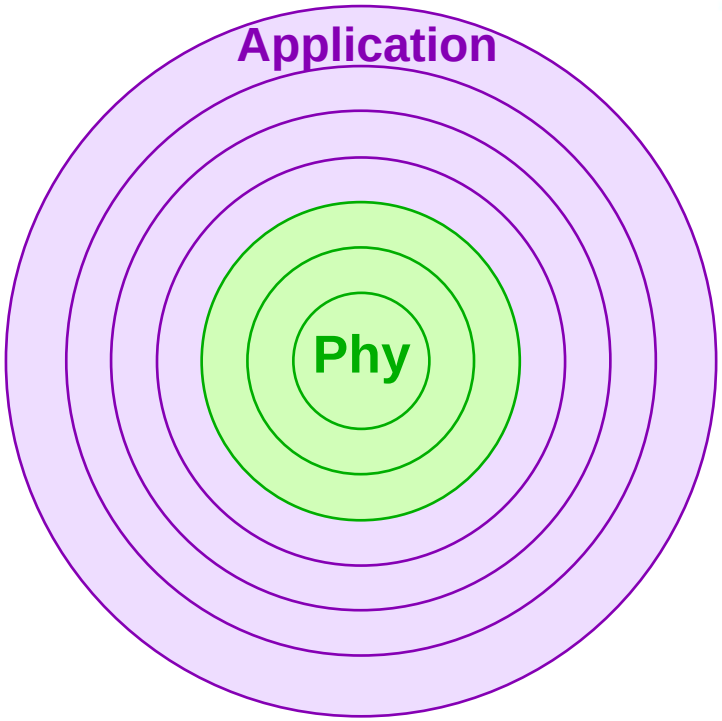


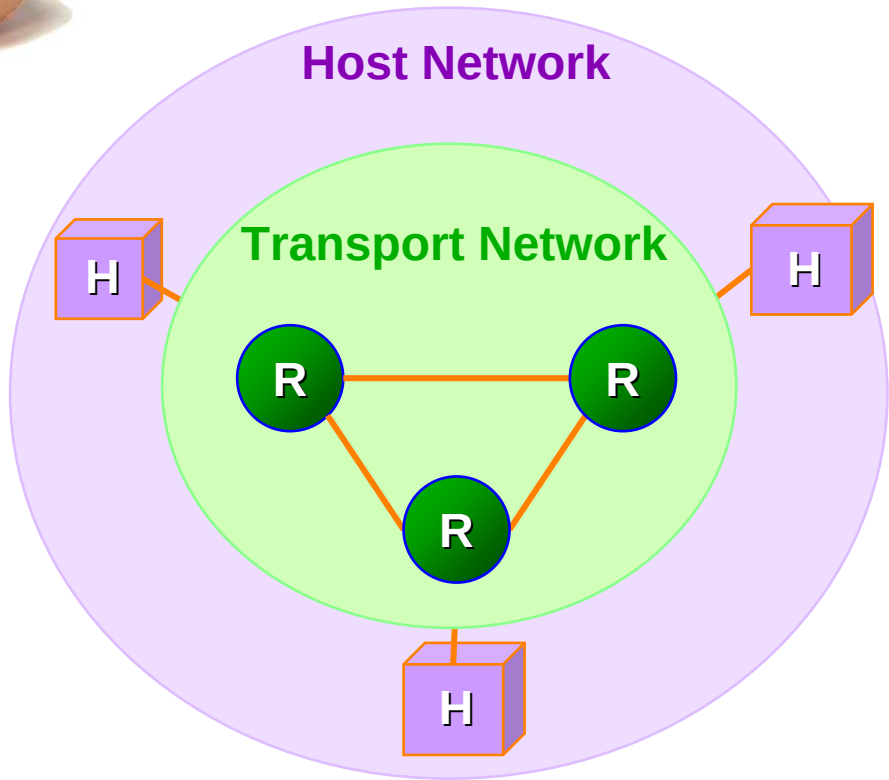


Graphical Presentation from Norway, 1976

Predating OSI

Topological Representations





The idea that

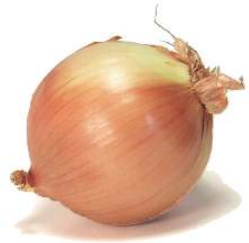
Networks have only two major components

Hosts and Nodes

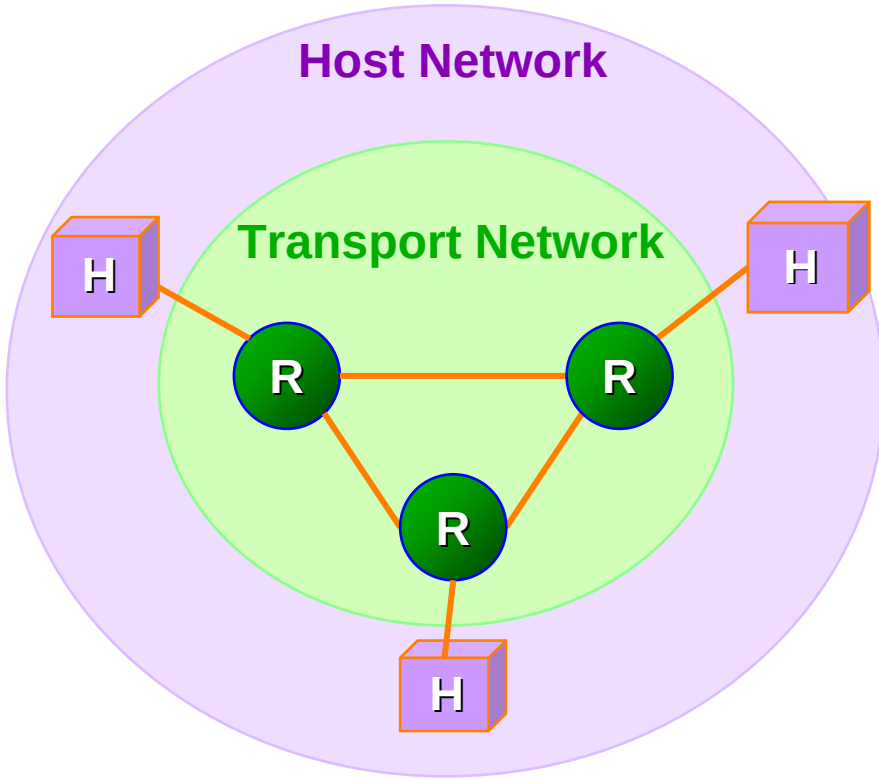
turned out to be Architecturally Dangerous

Sandwiches

The Danger of the Host/Node Divide



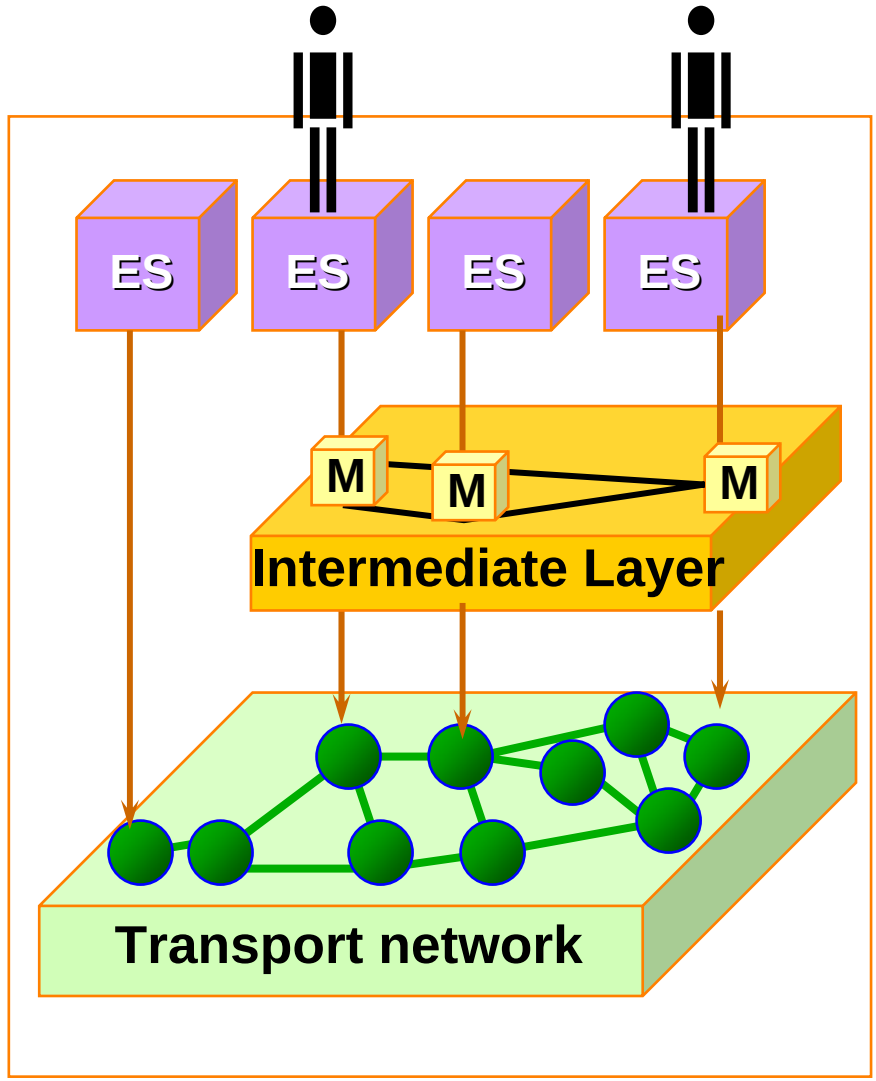
- Neglect the role of **Intermediate Layers**



What is Intermediate Layer?

A set of **intermediary** systems

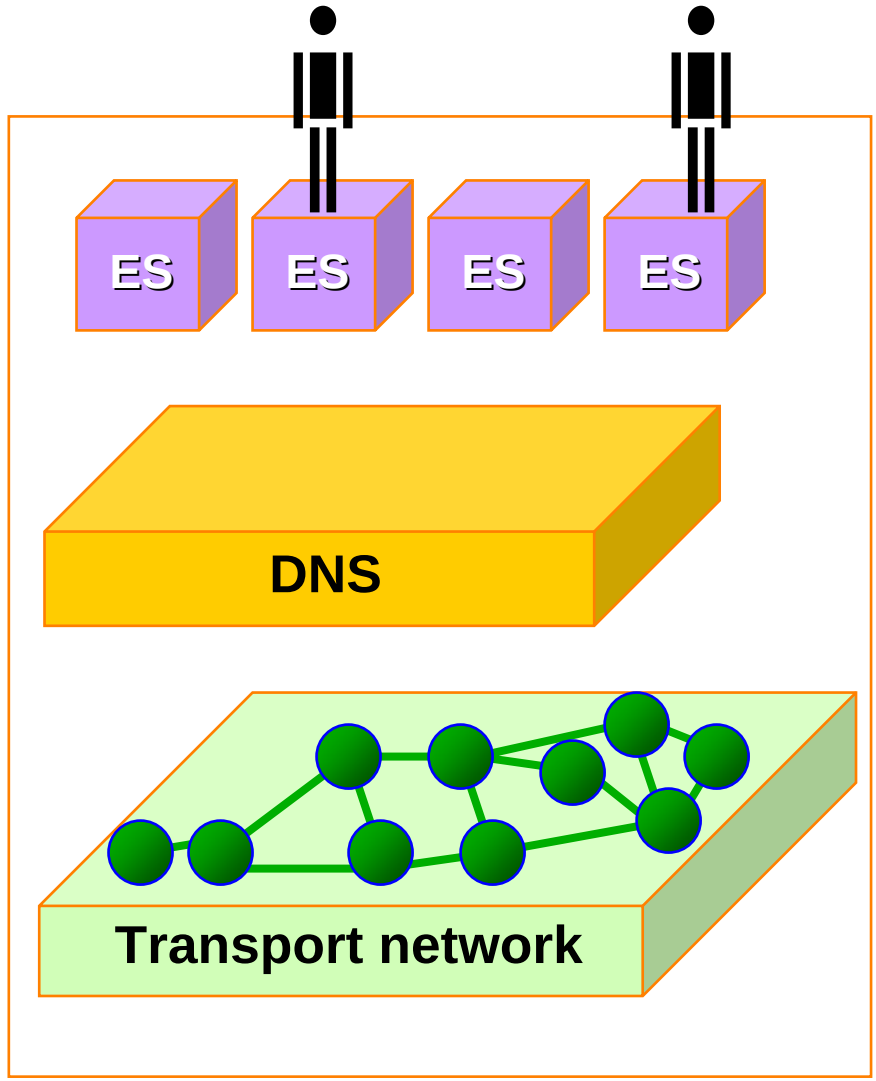
- **invisible** to the **end-user**
- **on-top** of the base transport network
- which all **conspire** to deliver a specific service
- forming a **topology**
- essential but **…**
  not compulsory



Intermediate Success Story?

Only one Intermediate Layer

- **Universal**
- **Invisible**
- **Well managed**
- **Unchallenged**

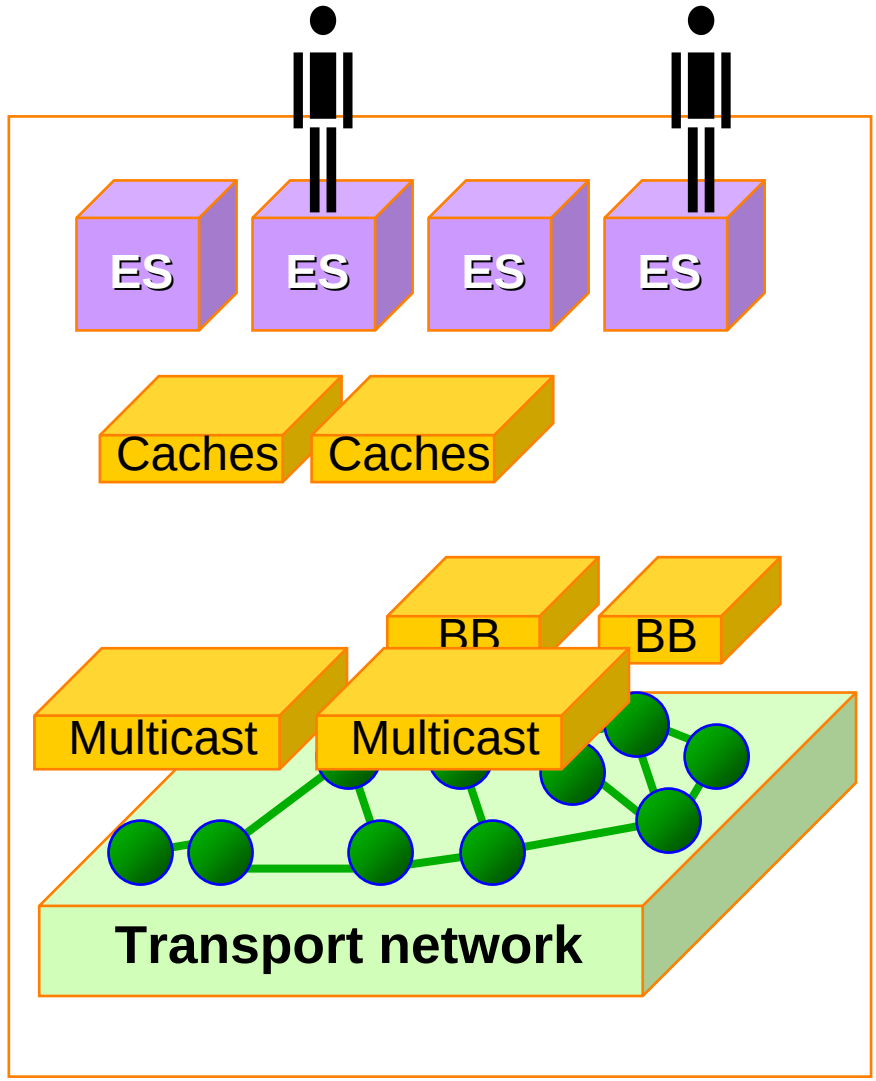


Intermediate Layer “Disappointments”?

Because

- Non-Universal
- Fragmented
- Non-open (proprietary)
- Difficult to manage

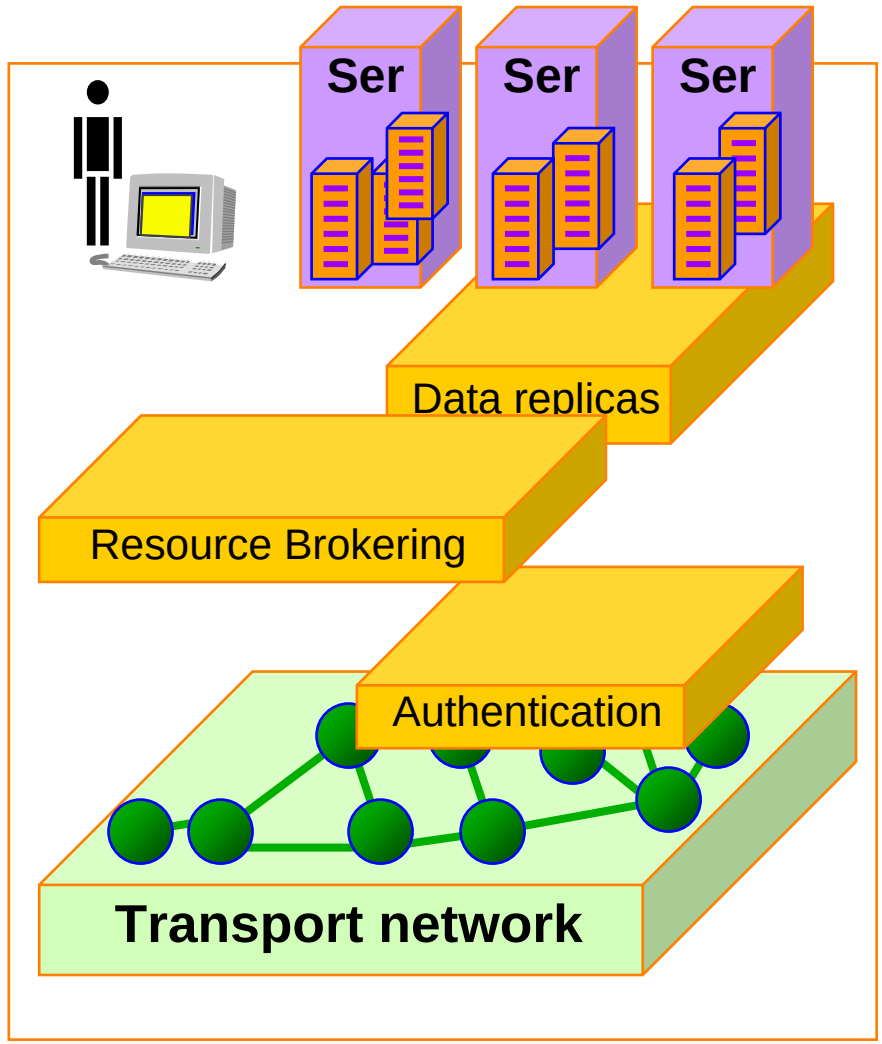
- **IP multicast**
- **Web caches**
- **Bandwidth Brokers**
- **…**
- **PKIs**



Grid Middleware Layers?

Issues

- **Topology Management**
  - Configuration
  - Changes
  - Optimization
  - Monitoring
- **Inter-domain Operation**



DNS apart, Intermediate Layers

- failed to establish **universal** services
- are often **poorly managed**

Dumb

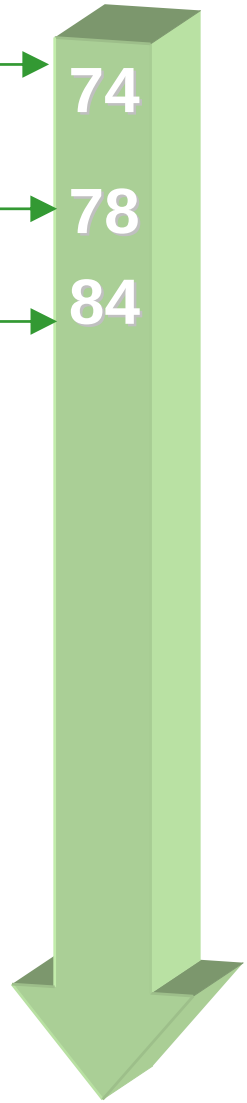
The Internet End-to-end Argument

Transport Level

V. Cerf / B. Kahn
TCP / IP separation → 74

M. Gien, H. Zimmermann
OSI Reference Model → 78

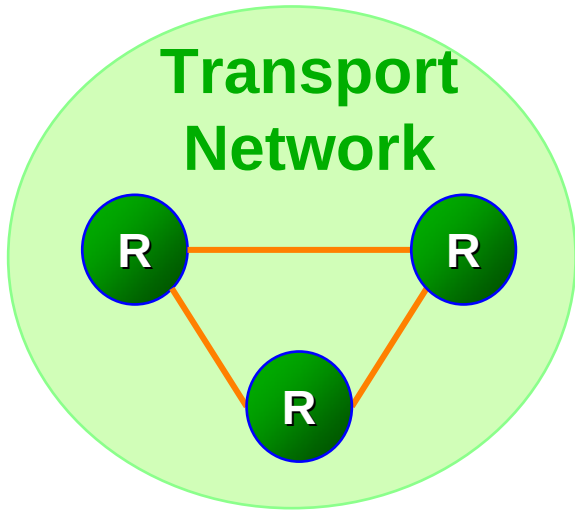
J. Salzer, D. Reed, D. Clark
End-to-End Arguments in System Design → 84



The Internet End-to-end Argument

“Intelligent” Hosts - “Dumb” Network

- No **Flow Control** / No **Buffering**
- No **Error Recovery**
- **Security** in End-systems
- **Addresses** carried unchanged



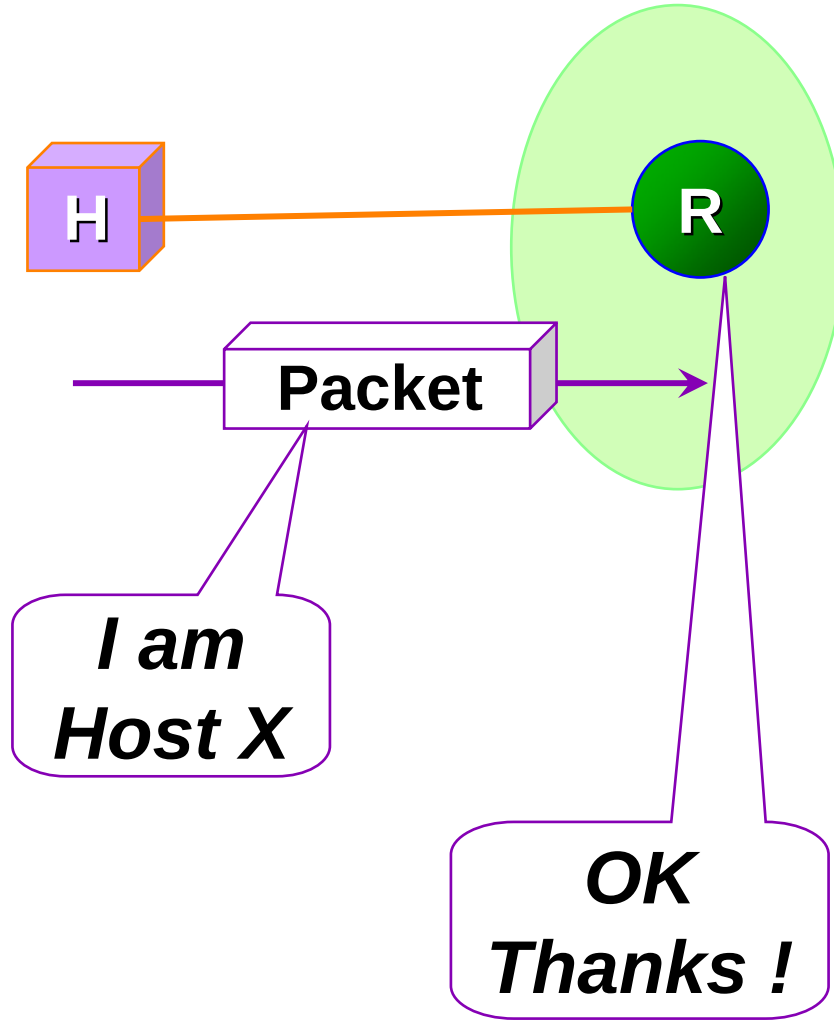
Addresses Carried unchanged

One consequence

1. **ES** set **themselves their source address**

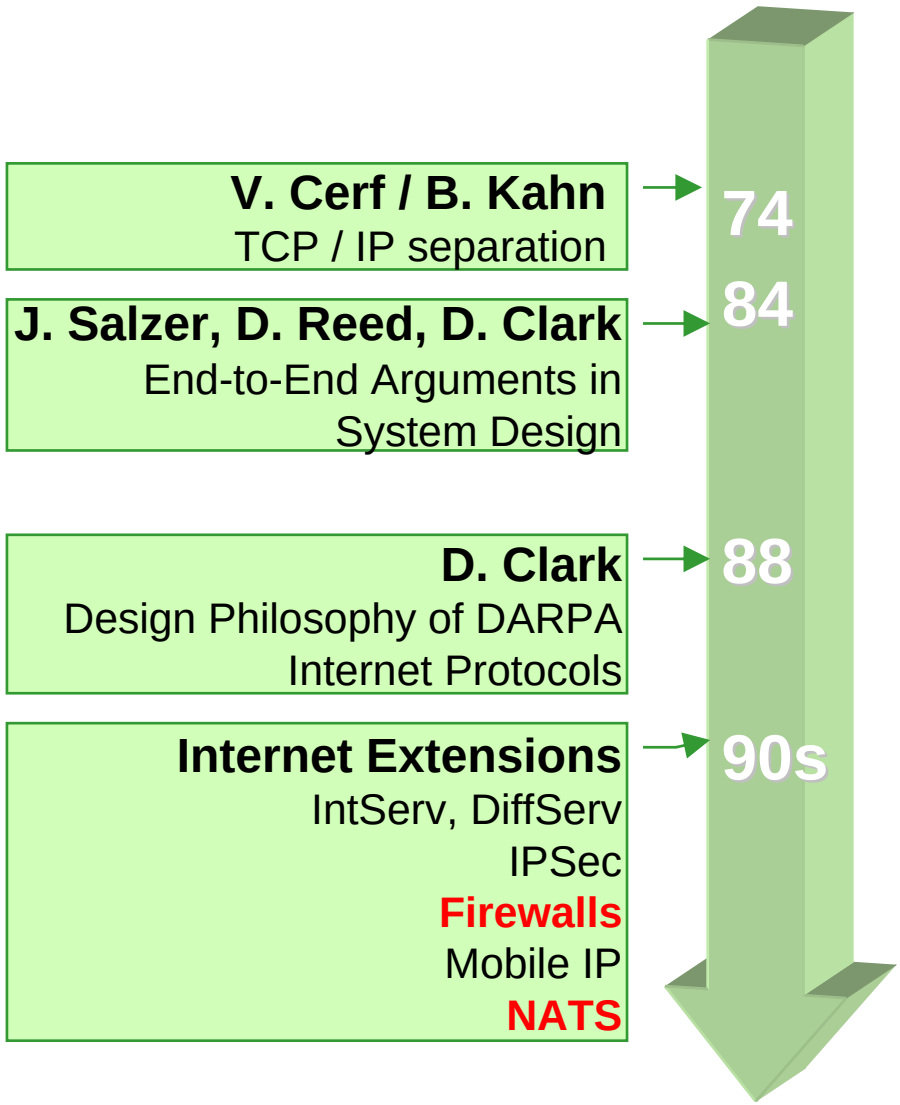
   unlike e.g. brave old X.25

2. **IPSec** was needed



Internet Architecture Extensions

Transport Level



Some “Good” and “Bad” Extensions

Opinion

Pose Serious Architectural Difficulties	No Serious Architectural Difficulties
1. **NATs**	1. **IPSec**
2. **Firewalls**	2. **MPLS**
3. **Web Caches** e.g. when attaching ads	3. **QoS** Diffserv, Intserv

Role of States

IP is stateless

- **Stateless (Connectionless)**
  - packets may be lost, miss-ordered
- **Stateful (Connection-oriented)**
  - no data sent before authorized by network (by means of call set up)

Internet (IP)
Web (HTTP)
=
Stateless

IP, HTTP Stateless Regular Behavior

- **IP switch**
  - take a packet, forward it, forget it …
  - take a packet, forward it, forget it …
- **HTTP server**
  - take a request, serve it, forget it
  - take a request, serve it, forget it

Predicting Load?

When you have

no memory of the past,

you cannot

predict the future

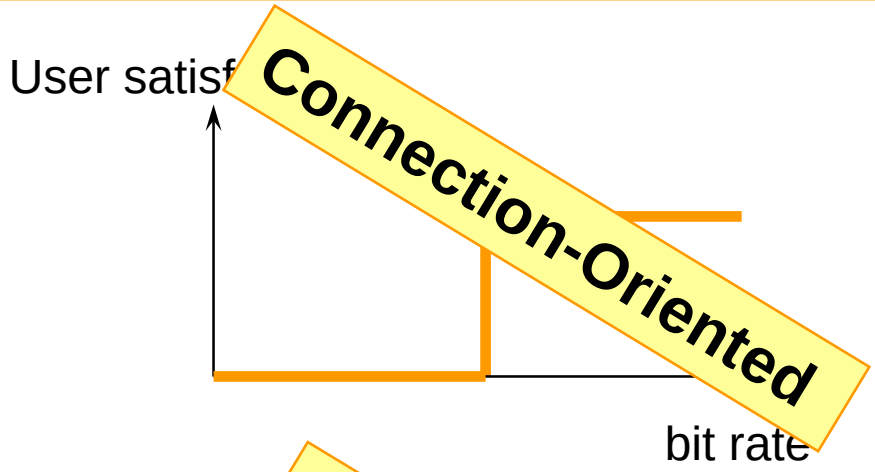
Efficiency or Perfectionism

Types of Applications

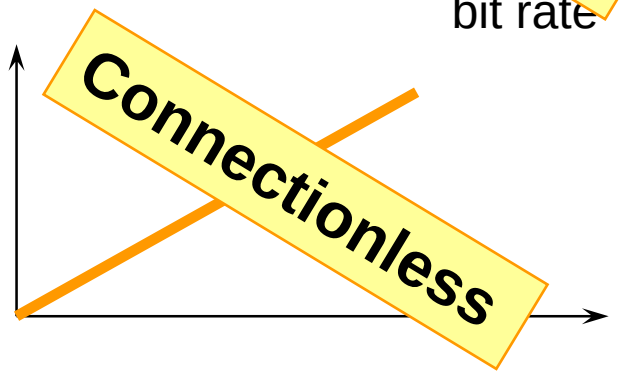
- ***Constant Bit Rate (CBR)***
  - e.g. PABXs
- ***Available Bit Rate (ABR)***
  - e.g. file transfer
- ***Variable Bit Rate (VBR)***
  - e.g. compressed audio, video

Quality of Service and bit rate

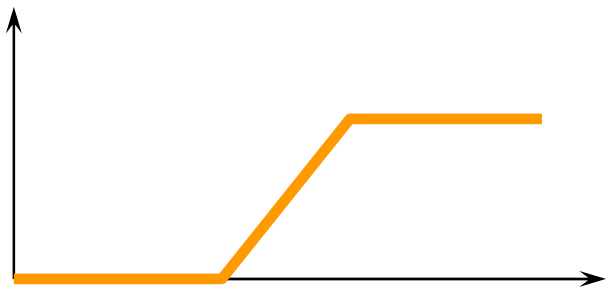
- **CBR applications**



- **ABR applications**



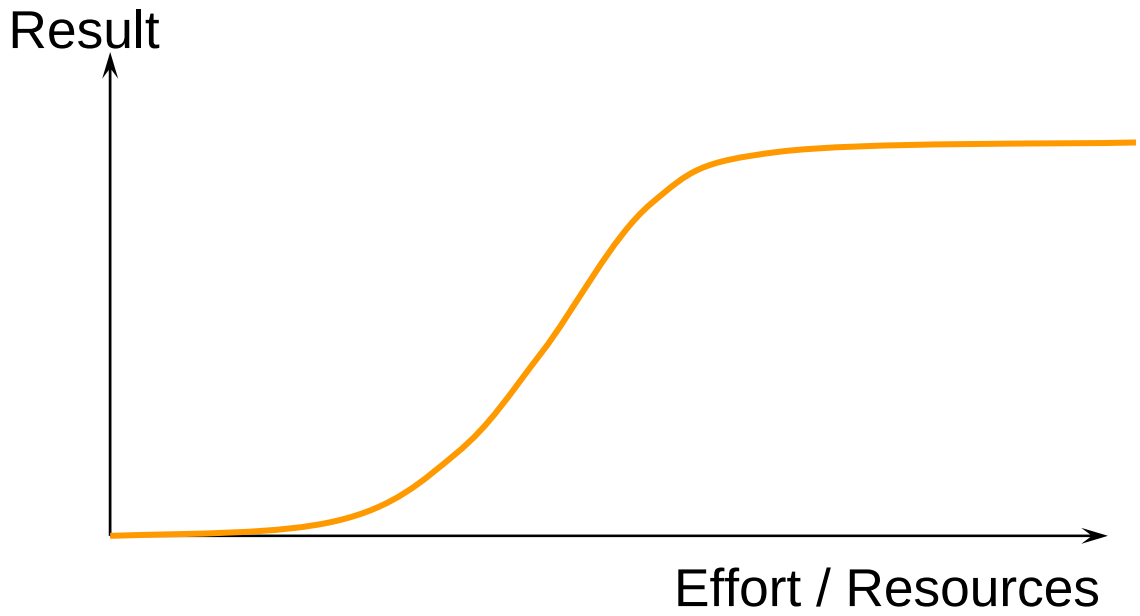
- **VBR applications**



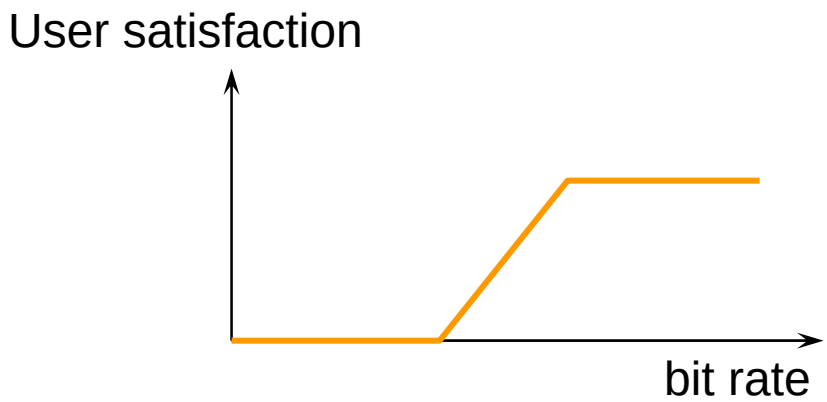
From Scott Shenker,
Fundamental Design Issues for the Future Internet

Fact of Life: Effort and Result

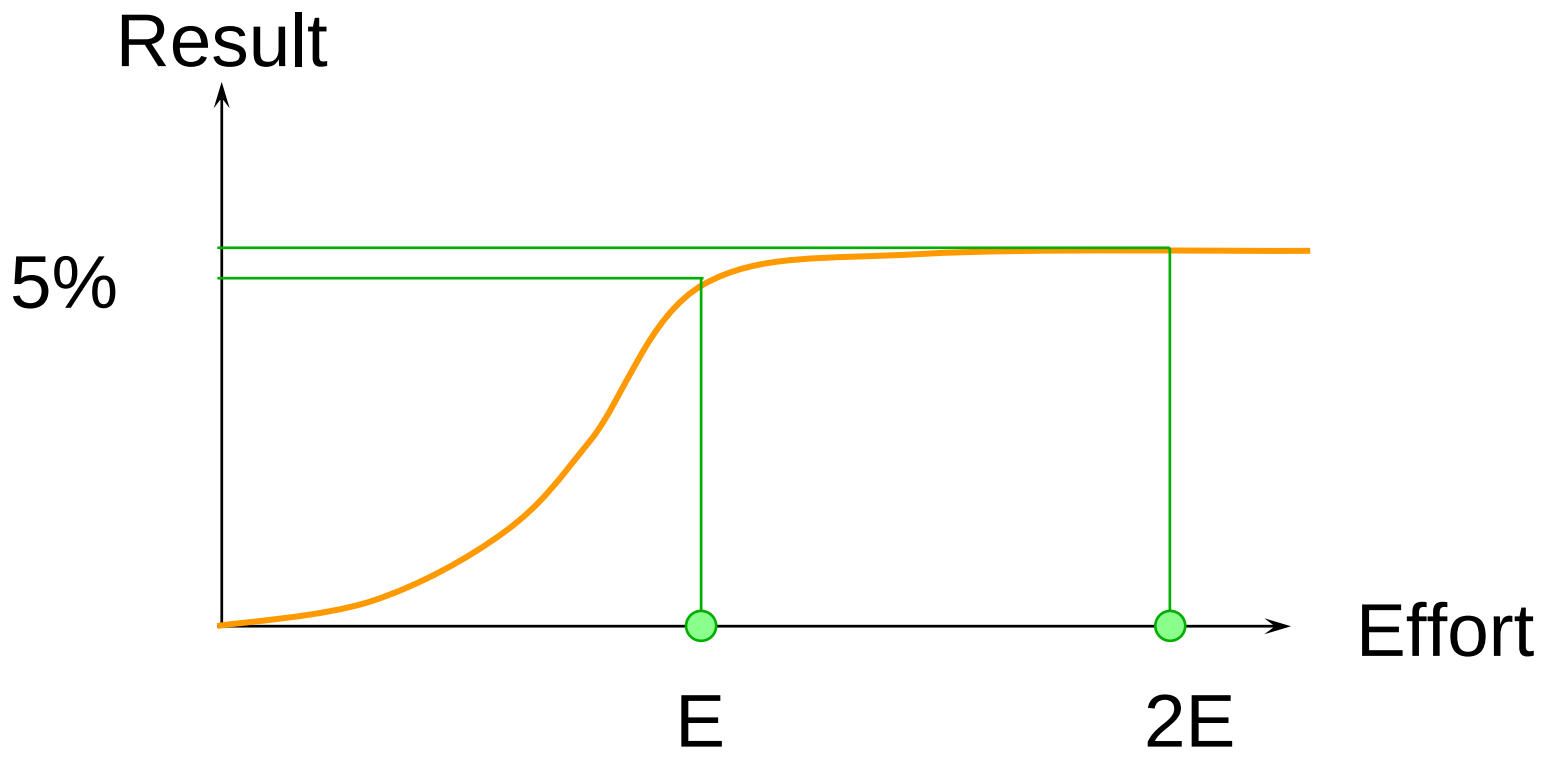
- **Any human undertaking**



- **VBR** applications

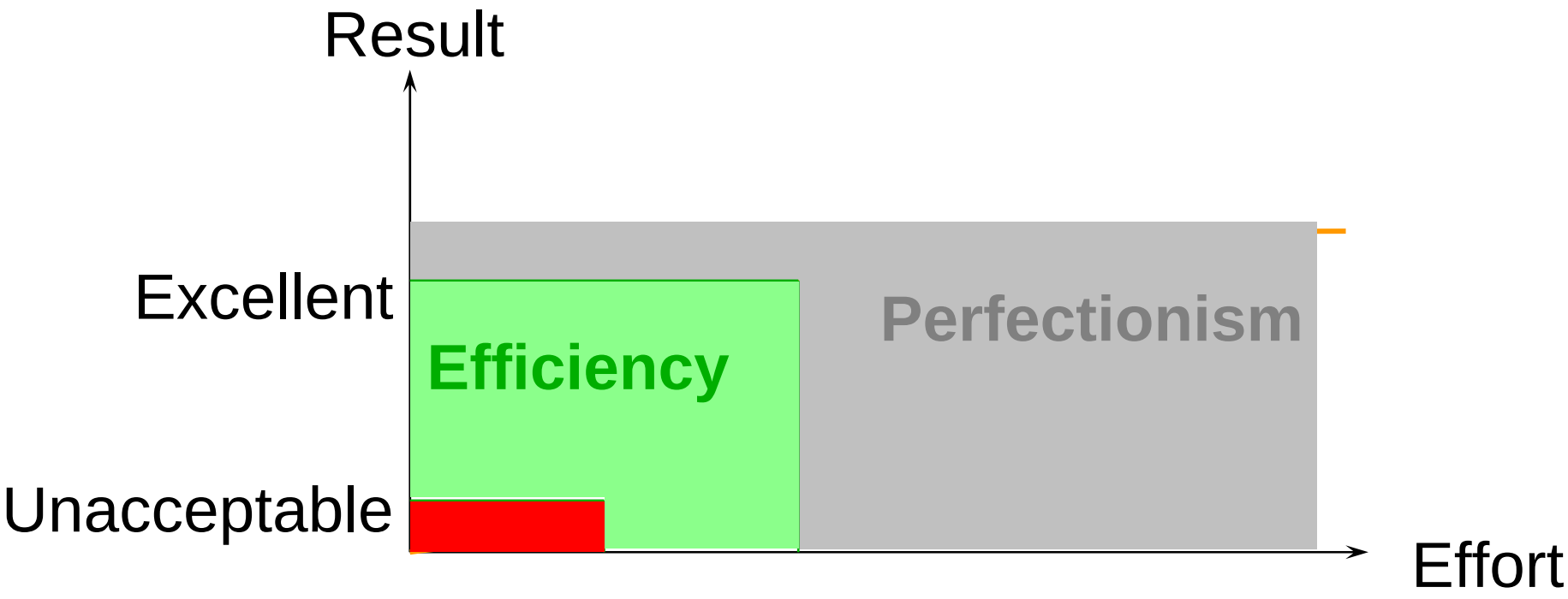


Fact of Life: Effort and Result



bit rate

Efficiency or Perfectionism



bit rate

- Stateful Networks are good at CBR, bad at ABR
- Stateless Networks are good at ABR and VBR, bad at CBR

Lories and TGV

- **Stateless systems (no reservations) scale well, but are bad at QoS**

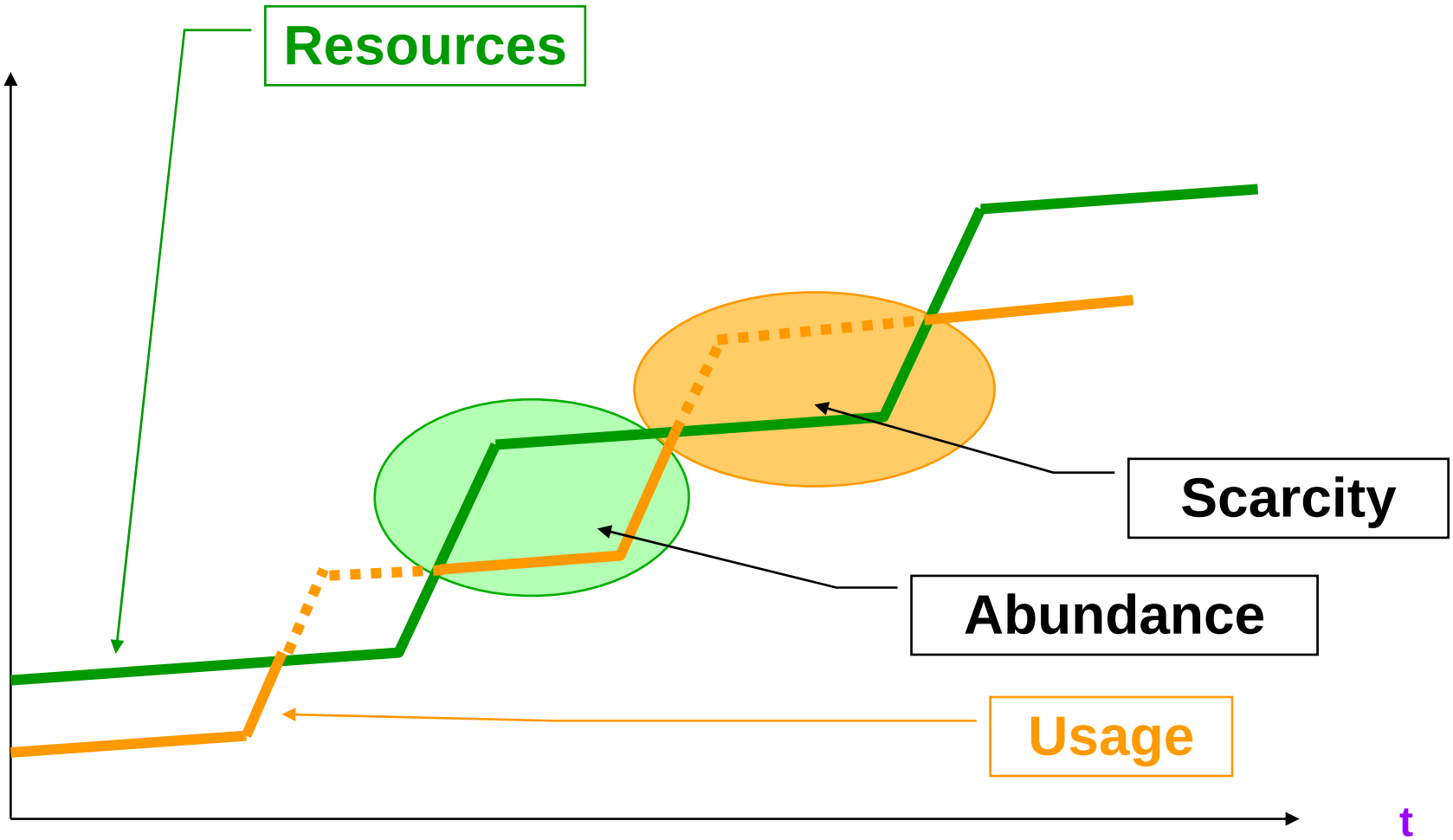
François Fluckiger

- **Stateless systems (no reservations) scale well, but are bad at QoS**

- **Stateful Systems (reservations) are good at QoS, but bad at scaling**

Abundance and Scarcity

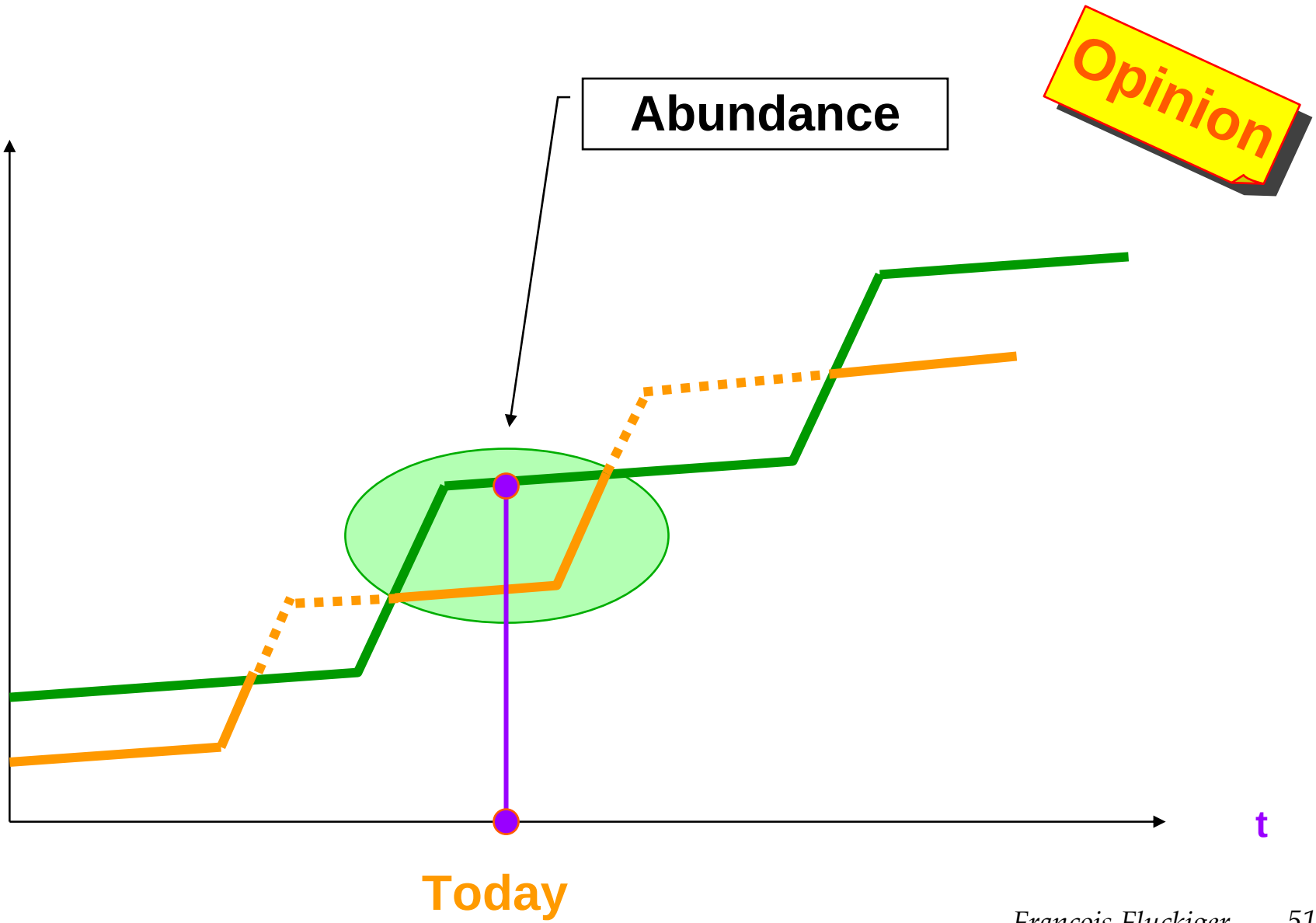
Resources and Usage



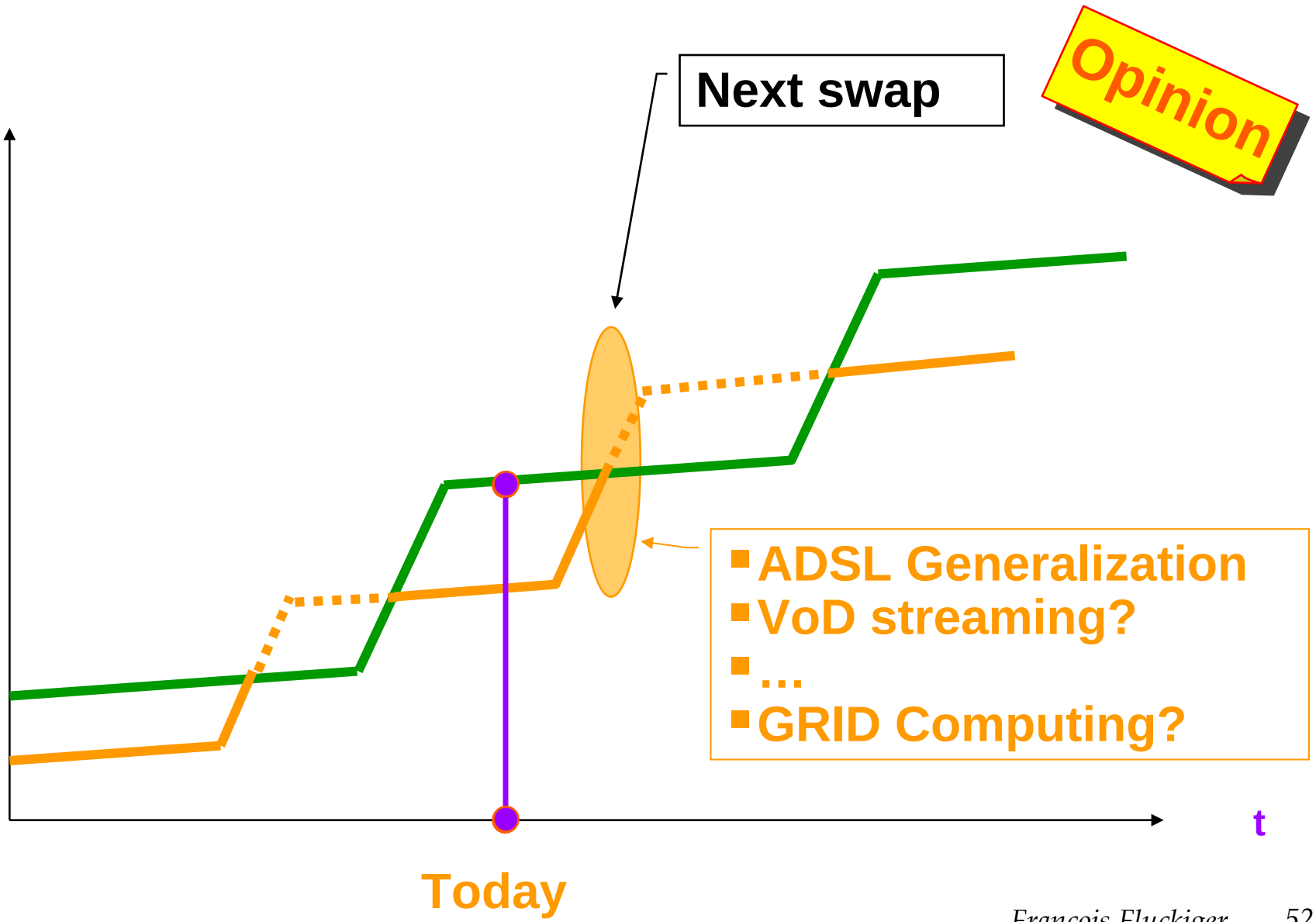
Observations

- **Core ISPs**
  - Capacity utilized at 12%
- **LANs**
  - Over-provisioned
- **Real problems**
  - Corporate **WANS** (ISP Managed Networks)
  - Networks with **Radio** sections
  - Wireless **Internet Telephony**

Resources and usage



Resources and usage



D-Day

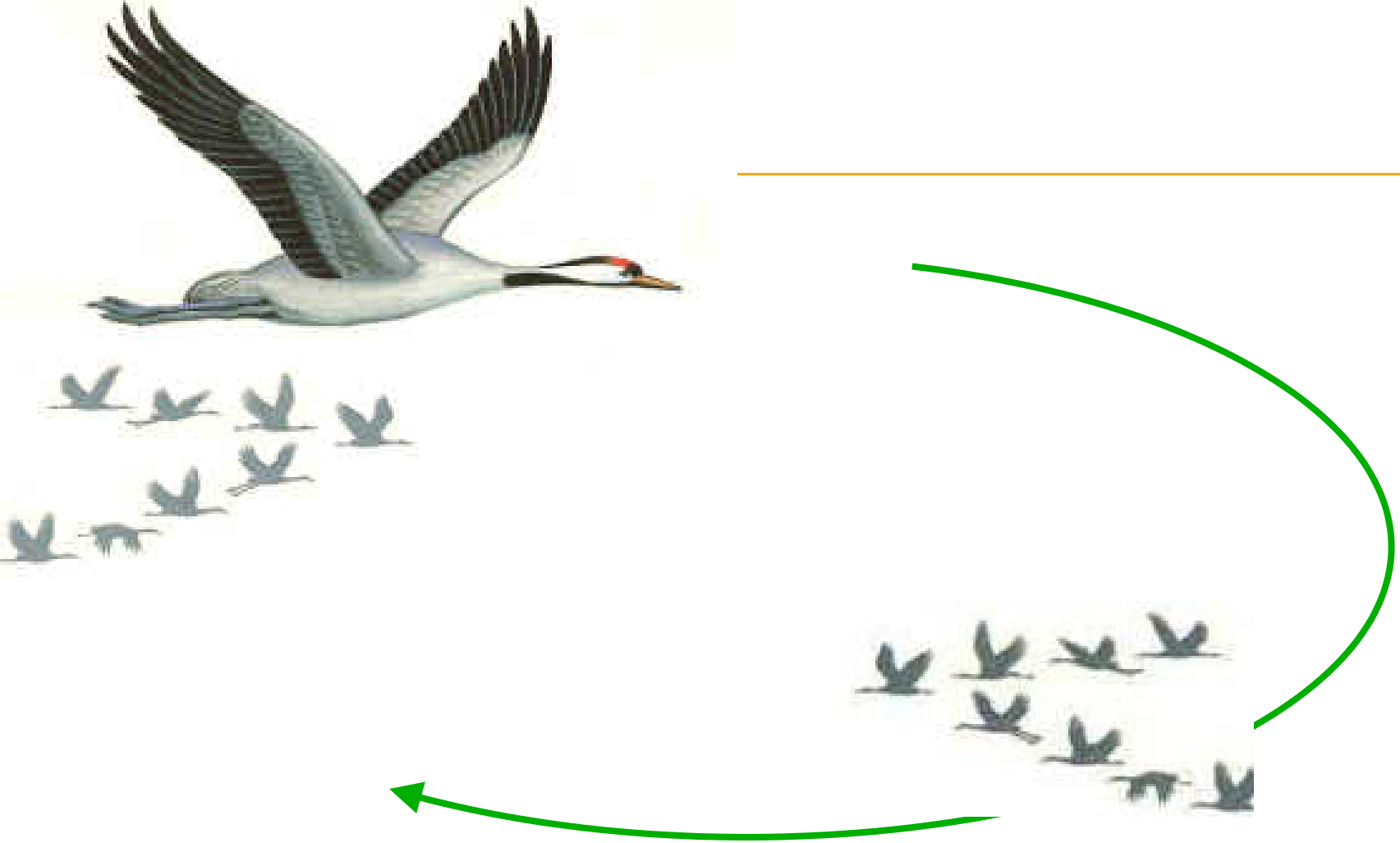
Entering the IPv6 era

Steven Wolf, NSF, 1988 Rare Conference here in CH

"Migration?"

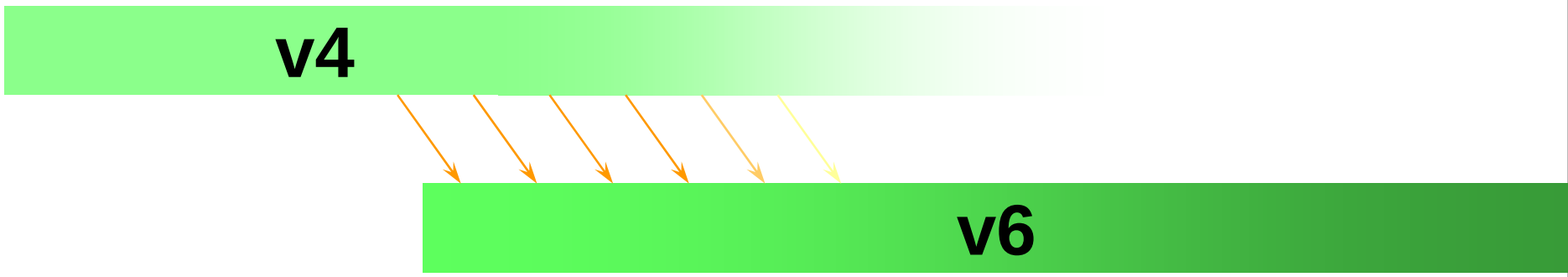
The things I know that migrate are

birds



"Let's speak about transition"

Transition

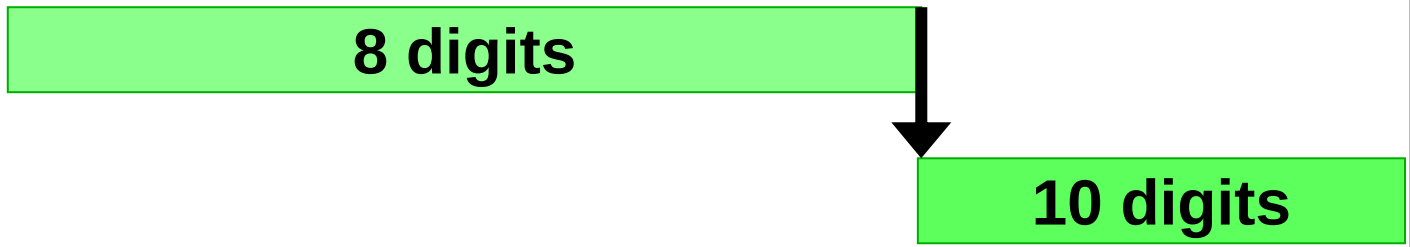


- Past attempts of smooth transition:
  - Xxx -> OSI
  - DECNet 4 -> DECNet 5

Flag-Day

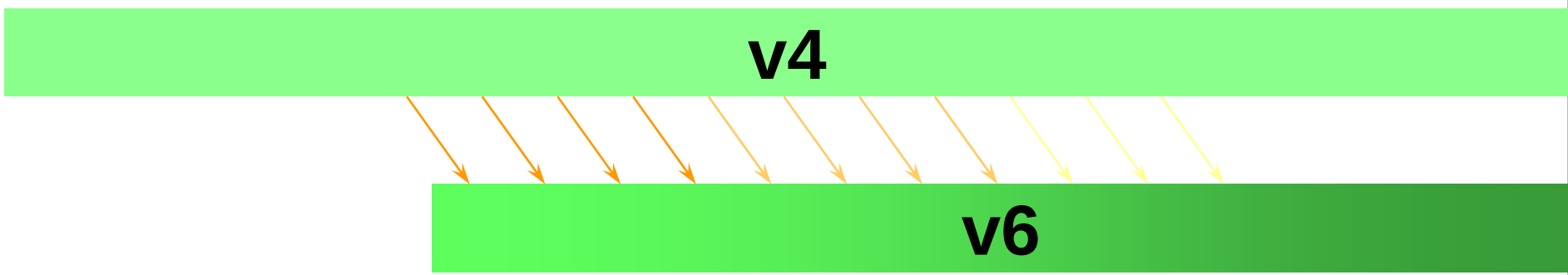
- **DARPA / Internet**

- **French Telephone Numbering**



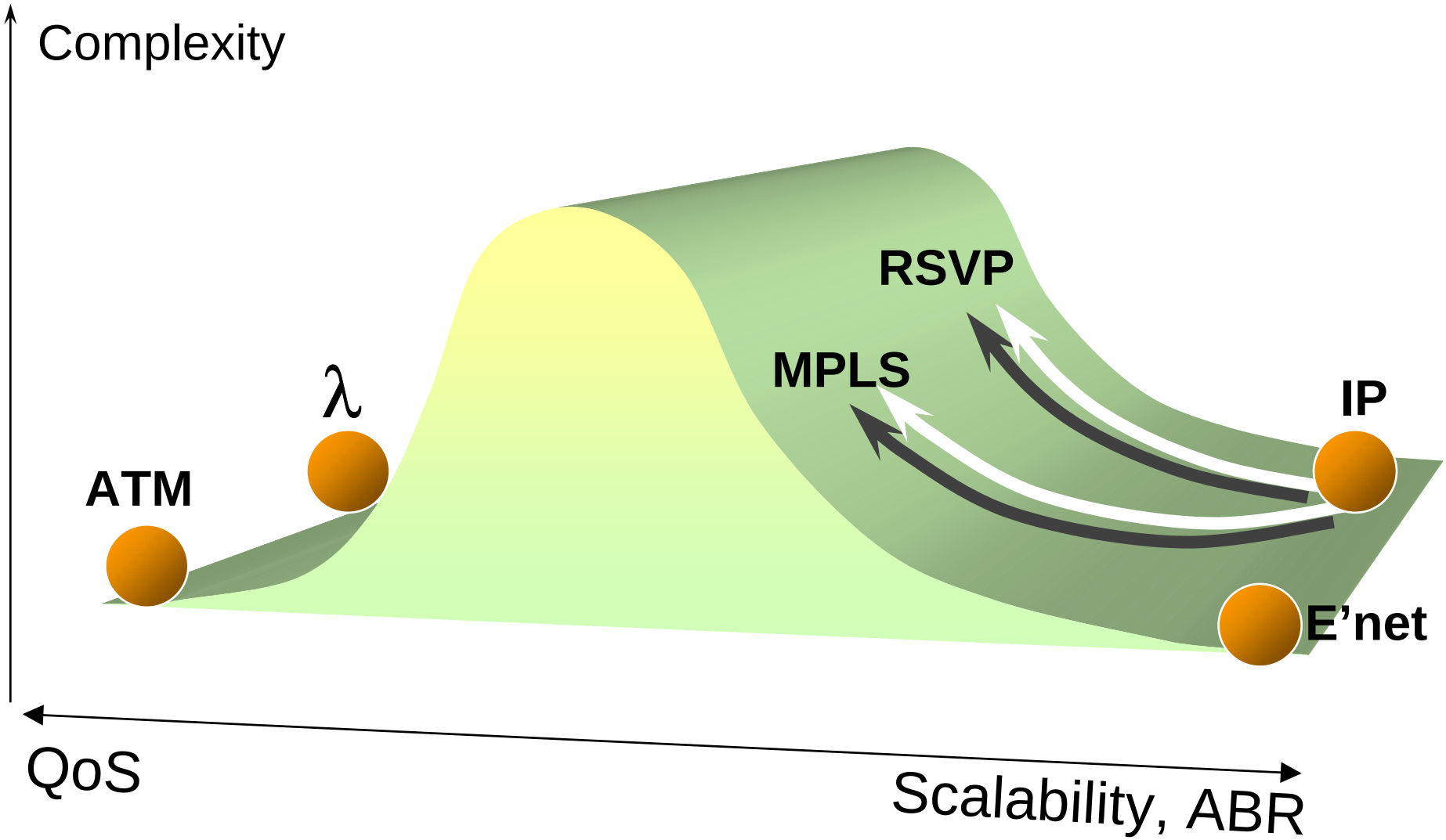
IPv6 Transition

- **Flag-day** no longer an option
- v6 transition is **complex**, **costly**
- Some specialists now talking of **Co-existence** instead of **transition**



- Most smooth transitions in Networking have failed so far
- Transitions may lead to endless co-existence

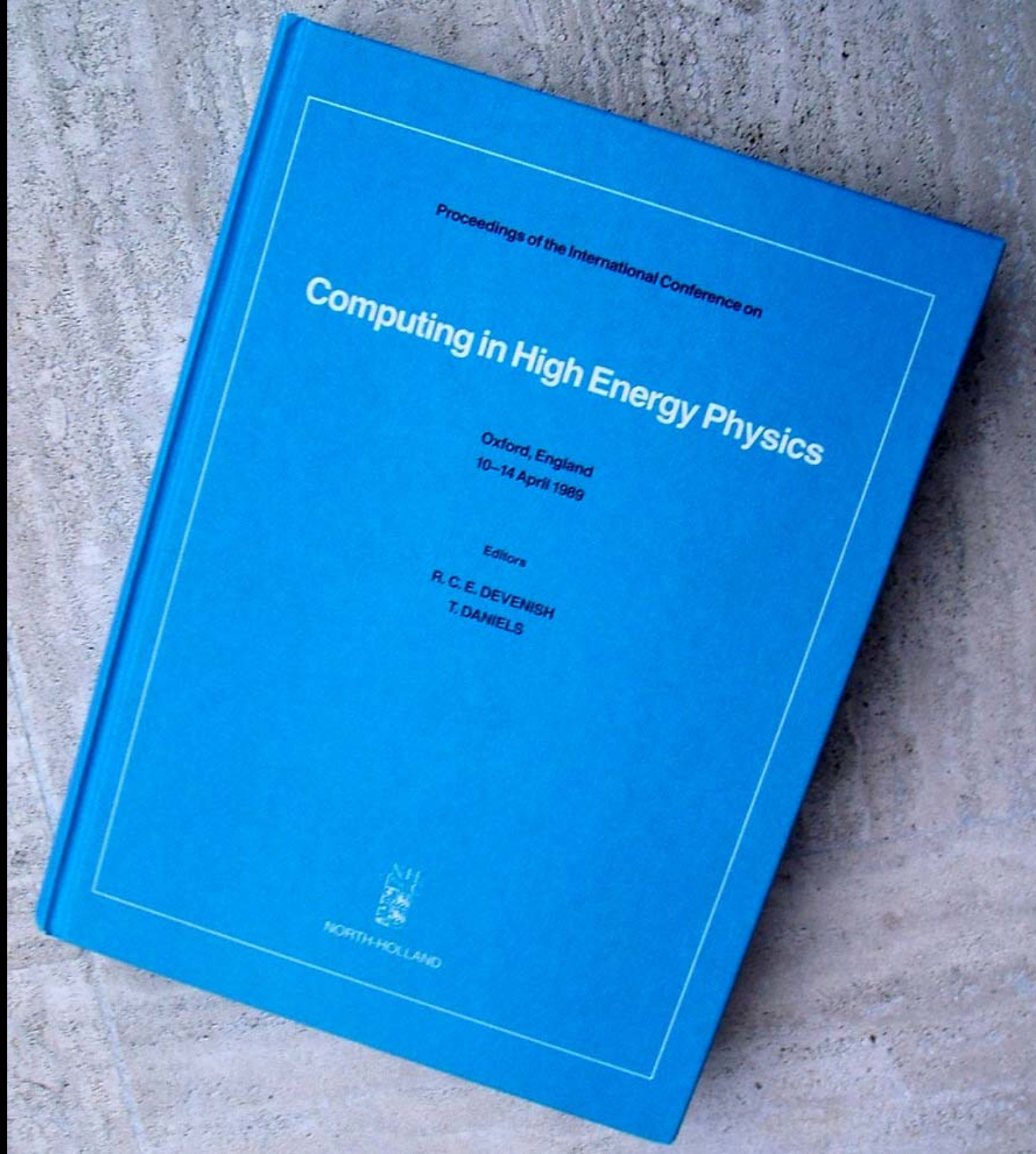
The Grass is always Greener on the other Side of the Hill


Complexity
RSVP
MPLS
λ
IP
ATM
E'net
QoS
Scalability, ABR

Directoies?

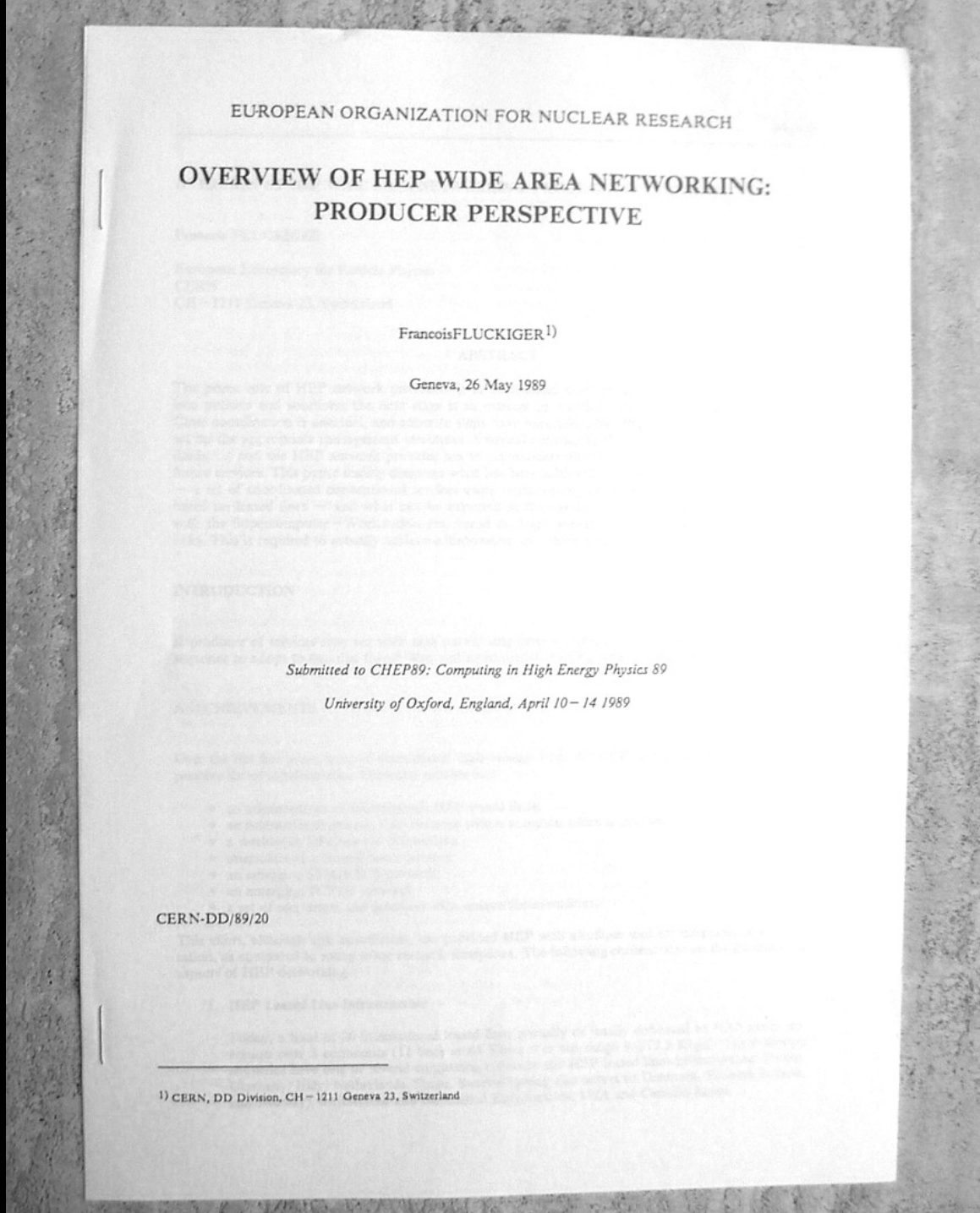
CHEP89

Oxford



Overview of HEP Wide Area Networking

F. Fluckiger



EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

OVERVIEW OF HEP WIDE AREA NETWORKING: PRODUCER PERSPECTIVE

FrancoisFLUCKIGER[1)]

Geneva, 26 May 1989

Submitted to CHEP89: Computing in High Energy Physics 89

University of Oxford, England, April 10 – 14 1989

CERN-DD/89/20

1) CERN, DD Division, CH – 1211 Geneva 23, Switzerland

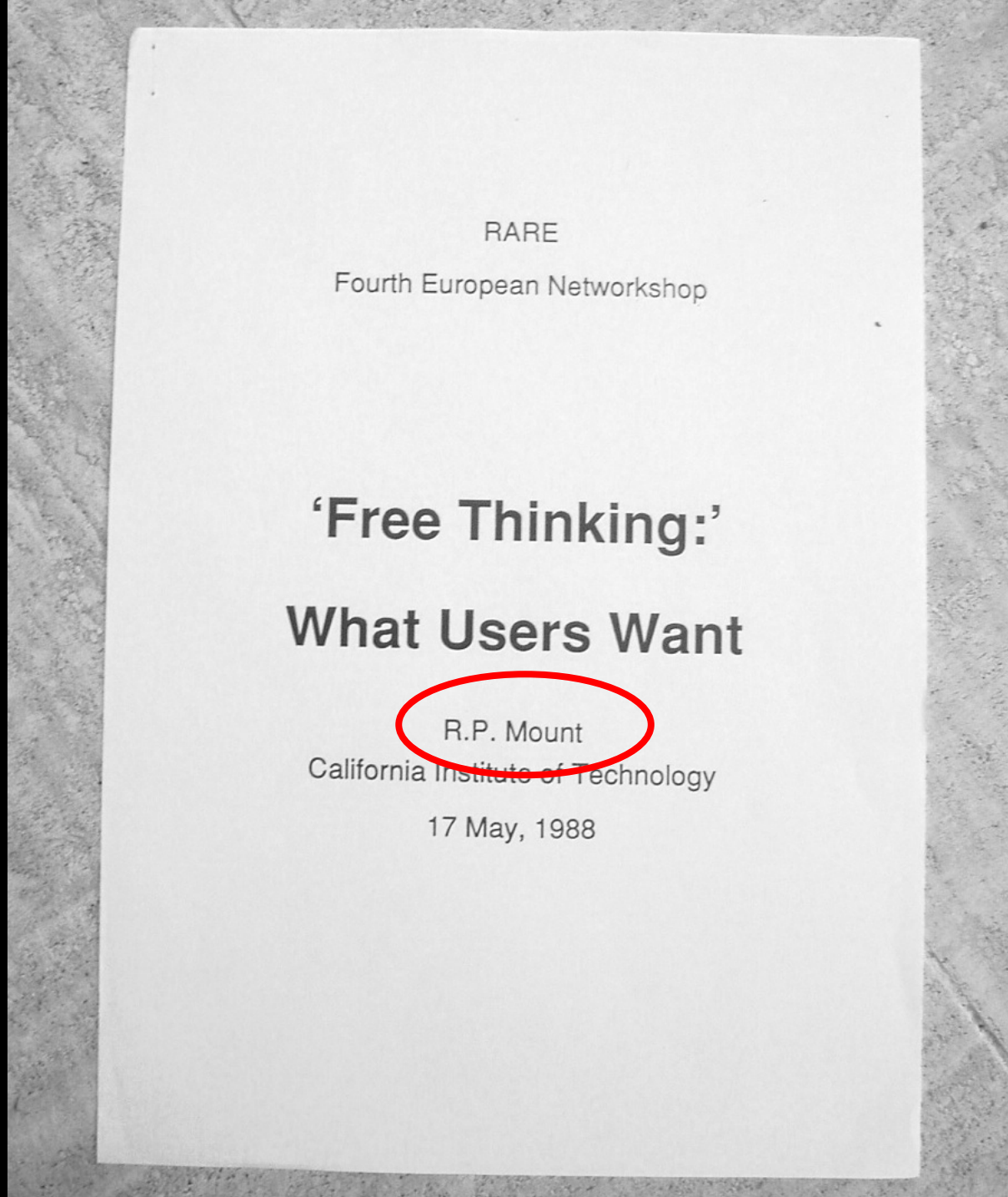
OSI is late.

It still deserves to remain a strategic direction

F. Fluckiger

RARE European Networking Conference

Les Diablerets May 1988



RARE

Fourth European Networkshop

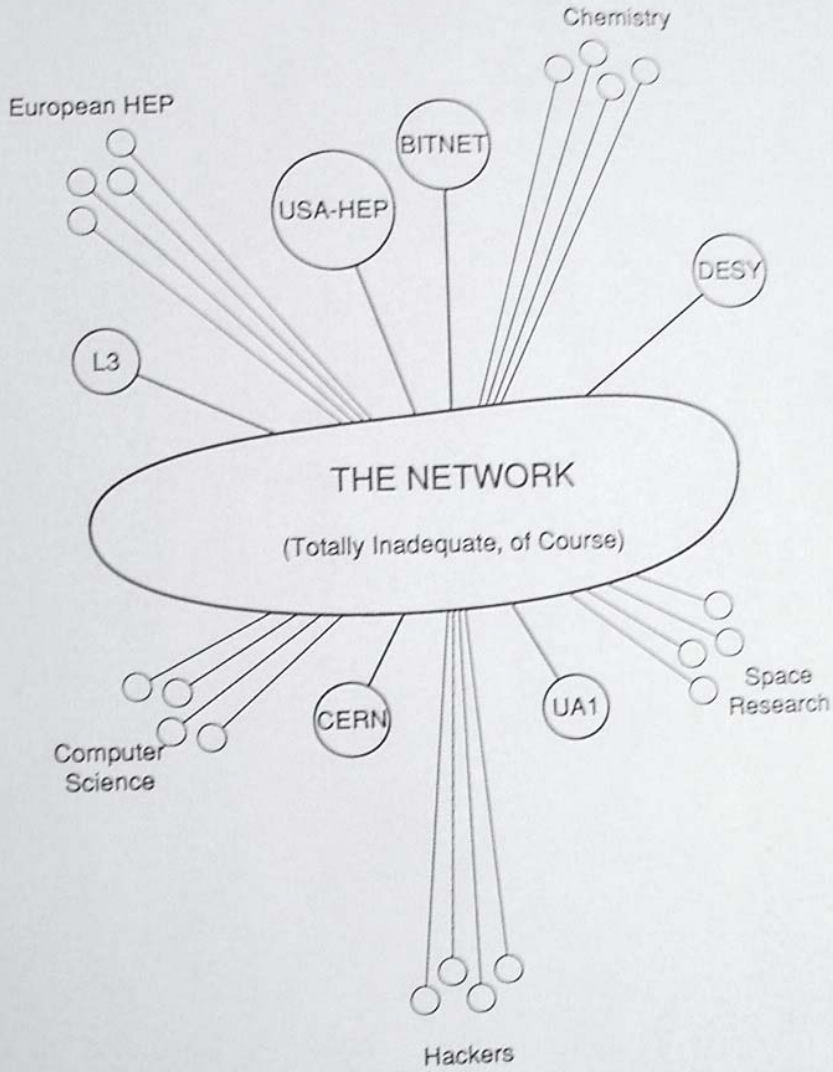
‘Free Thinking:’

What Users Want

R.P. Mount
California Institute of Technology

17 May, 1988

The Worst Possible Network



FE→ BC, DH, DW
From R. Mount, RHIC Conf, Los Alamos, May 88

What do Users Want?

- Network infrastructure priced realistically.
- General Purpose, high connectivity, network.
  - High total bandwidth,
  - Moderate bandwidth per user,
  - Management, directoies, nameservers, etc., etc.
- 'Mission-Oriented' networks where appropriate.
- Access to fibres (or G703) for special applications.

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- General Purpose, high connectivity, network.
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- 'Mission-Oriented' networks where appropriate.

- Access to fibres (or G703) for special applications.

DNS apart, No **universal**, Easy to Manage **Overlay** Layers	Services more Fragmented in future
Success Story **HTTP** and **IP** Same stateless philosophy	Application / Network compatibility: Key for successes of the future
Switched Circuits in **Core** never worked satisfactorily to support a IP	Skepticism for **switched λ** in Core Internet

Conceptual antagonism between QoS and Scalability / ABR	Future is in Stateless Technology with some stateful stuff… rather than the reverse
Oscillating Mismatch between bandwidth offer / demand	Next phase of scarcity will come
Smooth transitions in Networking have failed so far	Hard time for IPv6